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SOMMAIRE

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EMMANUEL DE MARTONNE

(1873-1955)

Emmanuel de Martonne s'est éteint à Paris le 25 juillet 1955 à l'âge de quatre-vingt-deux ans. Sa mort à mis en deuil non seulement la géographie française, mais la géographie mondiale, car ce savant était à l'échelle de la planète.

Emmanuel de Martonne, Professeur honoraire à la Sorbonne, Membre de l'Académie des Sciences, Président d'honneur à vie de l'Union Géographique Internationale, laisse derrière lui une œuvre scientifique colossale, mais laisse aussi dans le cœur de tous ceux qui l'ont connu beaucoup de regrets, de fierté et d'admiration.

Nous n'insisterons pas ici sur le rôle éminent qu'Emmanuel de Martonne a joué dans le monde géographique durant un demi-siècle environ, ni sur le souffle nouveau qui marqua les études de géomorphologie lors de la publication de son *Traité de Géographie Physique.* Nous voulons évoquer notre maître en Egypte. Emmanuel de Martonne y est venu en effet à deux reprises. D'abord en 1925 au moment, où, pour la première fois depuis la fin de la première guerre mondiale les activités scientifiques internationales se renouaient et où s'est déroulé au Caire le XI^e^ Congrès géographique international. A cette occasion il avait présenté la première version de la carte si importante de l'extension des régions privées d'écoulement vers l'océan dressée en collaboration avec L. Aufrère [1]. Il avait participé à l'excursion traversant la Chaîne Arabique du Nil à la Mer Rouge entre Qeneh et Qoseir [2].

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[1] Emm. de MARTONNE, *Extension des régions privées d'écoulement vers l'océan. C. R. du Congrès intern. de géogr.,* Le Caire 1925, t. III, p. 25-50.

[2] Emm. de MARTONNE, *Excursion à Qosseir, C. R. du Congrès intern. de Géogr.,* Le Caire, t. II, p. 185-195.

Le second séjour se place en 1946 quand il fut appelé par l'Université d'Alexandrie comme professeur en visite. Sous les auspices de notre Société nous avons pu organiser pour lui une excursion au Sinaï et nous pûmes voir avec émerveillement Emmanuel de Martonne, à près de soixante-quinze ans, et plus jeune que jamais, soutenir sa réputation de marcheur et de grimpeur infatigable. A son retour à Paris il relatait dans un article magistral ses remarques pertinentes [1].

Le souvenir impérissable d'Emmanuel de Martonne reste attaché à tous les coins du globe. La Société de Géographie d'Egypte s'associe aux voix qui émanent de toutes parts exaltant son œuvre et honorant sa mémoire.

Hassân AWAD.

[1] Emm. de MARTONNE, *Reconnaissance géographique au Sinaï, Bull. de la Soc. de Géogr. d'Egypte,* t. XXII, fasc. 3-4, Le Caire 1948 et *Ann. de Géogr.,* n. 304, 1947, p. 241-264.

THE SITE AND MODERN DEVELOPMENT OF BAGHDAD

BY

J. H. G. LEBON

BAGHDAD AND ITS REGION

Modern Baghdad, like its Abbasid predecessor, owes its importance to the potentially metropolitan character of the region within which it stands. For the upper part of the alluvial plain which has been deposited by the Tigris and Euphrates is firmer and drier than to the south-east, nearer the head of the Persian Gulf, where the twin rivers have been more prone to change their courses, to overflow and to nourish marshes. Contiguous, and to the east, is the alluvial fan of the lower Diala, which is readily irrigated by canals diverging from the gorge through the Jebel Hamrin. Since at least neo-Babylonian times, irrigation works have been more extensive and permanent on the upper plain than to the south-east. Thus from a capital city located in the vicinity of Baghdad the most important irrigation works in Mesopotamia can be controlled. Moreover, this region commands east-west routes leading from Iran to the Levant. From Kermanshah the most important crossing of the Zagros Mountains leads to Ba'quba on the Diala, and thence through Baghdad westwards to the «Desert Ports» of Ramadi, Kufa, An Najaf and Karbala. All the way to the edge of the Syrian Desert water and victuals are to be had. The route is not impeded by marshes, as to the south, and river crossings are limited to the main channels of the rivers Tigris and Euphrates. To the north, however, the desert reaches across both rivers as far as the piedmont zone of rainfall cultivation. These merits were appreciated by the founders

of the earlier capitals of Mesopotamia, or of empires based thereon : Babylon, Seleucia and Ctesiphon, the first 53 miles (89 km.), the latter two 25 miles (36 km.), from the present city of Baghdad.

For several recent centuries, during which Baghdad was a distant frontier and provincial town, liable to be besieged by Persian armies, and the extent of irrigation was reduced (after the Mongol invasions), the potentialities of the site and region were neglected. Moreover, during an era when the camel had been supplanted by the ocean-going ship, insecurity along the traditional caravan routes contributed yet further to diminish trade. But in the last century, the slow restoration of irrigation, the provision of roads and railways, the creation of Iraq as an independent state, and increasingly effective civil administration have engendered prosperity. Population has increased threefold in the last thirty years, and neighbouring towns along both rivers have grown concomitantly. The population map of Iraq reveals that Baghdad now stands in the midst of the most important urban concentration of the country, like a sun amidst satellites [1].

In their south-eastward courses, the Tigris and Euphrates converge to the latitude of Baghdad, and then again diverge. Until the Mongol invasions, navigable canals less than 40 miles long connected the two rivers. The Caliph Mansur, founder of the Abbasid city, could thus locate his capital in a web of navigable waterways as well as in the midst of the largest irrigated plain in the Near East. But other purely local features may have influenced his choice of site. Just north-west of Baghdad is a marsh, lying to the northwards of the ruined Babylonian *ziggurat* (or towered temple) known as Agarguf, into which discharged an ancient distributary or inundation canal of the Euphrates, now represented by the Saklawiya canal. Although this depression was largely cultivated in ancient times, it would be less easy to traverse on foot or mounted, especially in winter, in the days of unmetalled roads, than the better-drained land just to the south. To the south-east is the Diala, a considerable river liable to violent floods. Although better-controlled

[1] J. H. G. Lebon, *Population Distribution and the Agricultural Regions of Iraq, Geographical Review*, XLIII (1953), pp. 223-228.

during the Abbasid period than today, the region of its confluence, again, is at times impassable. It may be inferred that land routes tend to converge to a crossing of the Tigris near Baghdad. This convergence is aided by slight differences of altitude, imperceptible to the eye of a stranger, but known and recognized by the indigene from the observation of areas in which flood waters linger, and also demonstrated since 1920 by precise levelling. The Diala alluvial fan extends almost to the Tigris, and the lowest ground lies immediately eastward of the main river. But, along the westward courses of ancient Diala distributaries, originally natural, and later canalised, silt deposited during flooding and in the course of irrigation has built up two promontories, or natural causeways, higher by 1 to 2 metres than the general level. Along the northern of these drier ways passed the Khorassan road of the Abbasids, now followed by the Kirkuk railway. Along the southern passes the modern successor to the Khorassan road, *i. e.*, the road to Ba'quba, Khaniqin and Kermanshah (Fig. 1).

FROM THE FOUNDATION TO THE BEGINNINGS OF THE EXISTING PLAN

Mansur's original «Round City» was erected in A.-D. 754 (A.-H. 136) to the west of the river, between Karkh and Khadimain. Of it, not a trace is visible today. Within a hundred years of its construction, the populous suburb of Karkh had appeared just to the south, and what is today the bridge-head is also the oldest occupied quarter of the city. On the eastern bank, growth was slower; but the seat of government was transferred across the river by the Buyids about A.-D. 946 (A.-H. 334), when the Round City was falling into ruins. Here the centre of gravity has remained. During the first three centuries of its history, the city extended widely on both banks of the Tigris. On the eastern bank, the most important quarters were fortified by a wall in the latter half of the tenth century A.-D., which enclosed an area corresponding to the modern Adhamiya, Waziriya and the northern old city. But there were extensive suburbs beyond the walls, and the total urban area was three or four times greater than during the

Turkish period. On the right bank, also, suburbs and satellite towns were at times fortified [1].

The *madinat,* as the present old town is called, was delimited by the Caliph Mustazhir, who in A.-D. 1095 (A.-H. 487) built a wall which, many times damaged and repaired, endured until the days of the reforming *wali* Midhat Pasha (1868-1871). About this time, or early in the twelfth century, a bridge of boats was moored close to the site of the present Mamun (or old) Bridge, and was maintained almost continuously, till its replacement by a permanent structure only 15 years ago. From this epoch of the fixation of the main Tigris crossing and the outlining of the old town, features of plan which have persisted until today can be discerned. In the early thirteenth century A.-D., and close to the bridge-head, the oldest fabric still standing in Baghdad was built, *viz.,* the college founded by the Caliph Mustansir, known as the Mustansiriya, now being restored. Just after the Mongol invasions, the Greek slave ruler Mirjan built, in the heart of the *madinat,* the mosque which bears his name and the adjacent Mirjan Khan (now restored as the Museum of Arab Antiquities). Around these ancient buildings are the chief bazaars in which the commerce of the city was concentrated until the twentieth century, although the buildings used are not more than 100 years old. The area adjacent to the old bridge, on the east bank, has thus persisted as the commercial focus for about 800 years. The area of modern Karkh, apart from the century following the Mongol devastation, seems to have been continuously occupied since at least the ninth century, and its mediaeval wall enclosed an area almost as large as the modern *madinat.* But it was unwalled in 1537 (when a pictorial map preserved in Istanbul was drawn) [2], and its latest wall was erected no earlier than the rulership of the Mameluke Pasha Suleiman the Great (A.-D. 1780-1802) [3]. Thus, the plan of modern Baghdad preserves nothing from the first and grandest four centuries of its history. Even at the end of the eleventh century A.-D., when the present *madinat* was demarcated by the Caliph Mustazhir, the city had suffered two destructive sieges, and differed greatly in outline from the days of the great Caliphs. For, although greater public buildings were constructed of baked brick and tile, the majority of private dwelling houses and commercial buildings were of sun-dried bricks. After being damaged and deserted, the winter rains and floods destroyed all traces even of foundations and streets after a few years (*vide infra*).

(1) G. Le Strange, *Baghdad during the Abbasid Caliphate,* 1900, especially c. XIII.
(2) Baghdad at the Time of Sulaiman the Magnificent, 1537 A.-D., 944 A. H., drawn by Naṣuḥ al Silahi, reproduced in *Atlas Baghdad* (in Arabic), edited by Dr. Ahmed Souza, Survey Department, Baghdad, 1953.
(3) S. H. Longrigg, *Four Centuries of Modern Iraq,* p. 220.

THE SITE

The original site of Baghdad exemplified all that is normal on the flood-plain of a great river (Fig. 1). On either side of the channel are natural levees, sloping away gradually from the river itself. The slope ends about 2 km. from the water. Both in Karkh and on the eastern bank, settlement began and has tended to concentrate on the levees, partly because of the benefits to be derived from access to the navigable waterway, and partly for greater security during floods, for it is an advantage to be inundated to a depth of one metre instead of three or four. During the golden age of Abbasid rule, and again later, until the Mongol devastation, when the city spread for several miles away from the river on both banks, it may be presumed that the large diversions upstream into the Dejla and Nahrwan Canals, and the maintenance of high embankments along the levees, provided a measure of security from floods. (The Buyid Mu'izz-ad-Dawlah about A.-D. 946 [A.-H. 334] built great dykes which are eulogised by the chroniclers of his time) [1]. Nevertheless, the Arab historians record several inundations of particularly disastrous magnitude, which were as effective as sieges and sackings in destroying the traces of earlier building. Thus, after recording the flood of A.-D. 942 in western Baghdad, due to breaches in the Euphrates embankments, Le Strange comments that

(1) G. Le Strange, *op. cit.,* pp. 233-234, 319.

« floods were wont periodically to lay Baghdad in partial ruin» [1]. Again, in A.-D. 1174 (A.-H. 569), after forty days of heavy spring rainfall in the Mosul region, the whole of Baghdad was flooded, and many houses collapsed. Floods are particularly efficacious in obliterating the traces of former building in unbaked bricks. In this respect, Baghdad differs from the temporary Abbasid capital of Samarra, which was founded, erected, occupied and deserted within a period of forty years in the ninth century A.-D. Samarra stands on bluffs above the reach of floods. Its street plan can be followed on foot, and is disclosed with the utmost fidelity by air photographs, a thousand years after it became deserted.

Baghdad could also spread widely, and remain partly unfortified, because a firm government could repress civil disorder and police adequately. Later, as the Caliphate tottered, to be succeeded by the less adequate government of Turcomans, Mongols, Persians and the Ottoman Turks, the surviving inhabitants cowered behind the town walls of Karkh and the *madinat*.

Whilst the outline of the city waxed and waned, the more continuous occupation of land on either side of the bridge gradually raised the level of the surface. Contoured maps, drawn from the heights established along the lines of levelling which have been carried along the streets of the *madinat* and Karkh, reveal very clearly that the accumulation of rubbish has raised ground level from 1 to 4 metres in the *madinat*, and locally as much as 10 metres in Karkh. During the Turkish period, when flood control was even less adequate than during the preceding Mongol and Turcoman periods, the built-up areas of Karkh and the *madinat* were prudently confined to these artificially elevated areas, and the outline of the inhabited areas of Karkh and the *madinat* (which were considerably smaller than the areas enclosed by the walls) changed but little, for about five centuries. After the variations of plan during the Abbasid era there began a period almost equally long during which the occupied area changed but little. Whilst floods remained uncontrolled, the population clung to these limited areas, and the attachment

[1] *Ibid.*, p. 44.

tended to intensify, because as the occupation continued, the ground became still higher [1] (Fig. 1).

Moreover, stabilisation of the occupied area concomitantly fixed the river's course between Karkh and the city proper. It is known that the form of the meanders both above and below the *madinat* have changed since the days of the Abbasids : in part, doubtless, as a consequence of the greater destructiveness of floods after the ancient canals and controlling works were demolished. But for two miles through the built-over areas, the foundations of the riverside buildings have checked erosion and overflow; and behind the natural levees are accumulations raising the surface above all but the greatest floods. A distinct narrowing of the channel has clearly been caused by gradual accretion on to the bed, and has shortened the span to be crossed by the bridge of boats. A geographical momentum of a rather unusual kind thus caused the built-up area to remain static after the frequent changes between the eighth and the eleventh centuries. Particularly during the Turkish period, the area occupied by buildings on both sides of the river varied little.

Only a rudimentary method of flood control was practised during the Turkish period. The contoured map of Baghdad and its environs reveals that a broad, shallow natural channel passes just east of the old city between the eastern levees of the Tigris and the foot of the Diala alluvial fan (Figs. 1 and 2). Southwards, this elongated depression meets the Tigris just below the Karrada loop, and the Diala near its confluence. This natural channel could be used to pass a discharge in excess of the amount that could be safely carried by the Tigris itself. Thus it became the practice to breach the levees on the left or eastern bank a few miles above the city when flood waters threatened. Sandbagging the gates in the city wall ensured that no water penetrated into the *madinat*, and the released waters passed safely the eastward, to rejoin the Tigris

[1] The outline of the built-up area in 1750 was shown in a rather generalised way by Carsten Niebuhr, in the map accompanying the French edition of his *Travels in Arabia*, Amsterdam, 1766. This map is reproduced, with Arabic names, in Dr. Souza's, *Atlas*, p. 14.

near the Diala confluence. The immunity of Karkh was assured, because the level of water in the main channel below the breach could be kept below the top of the western embankments. When Midhat Pasha demolished the city walls in 1868, he built a *bund* just outside the

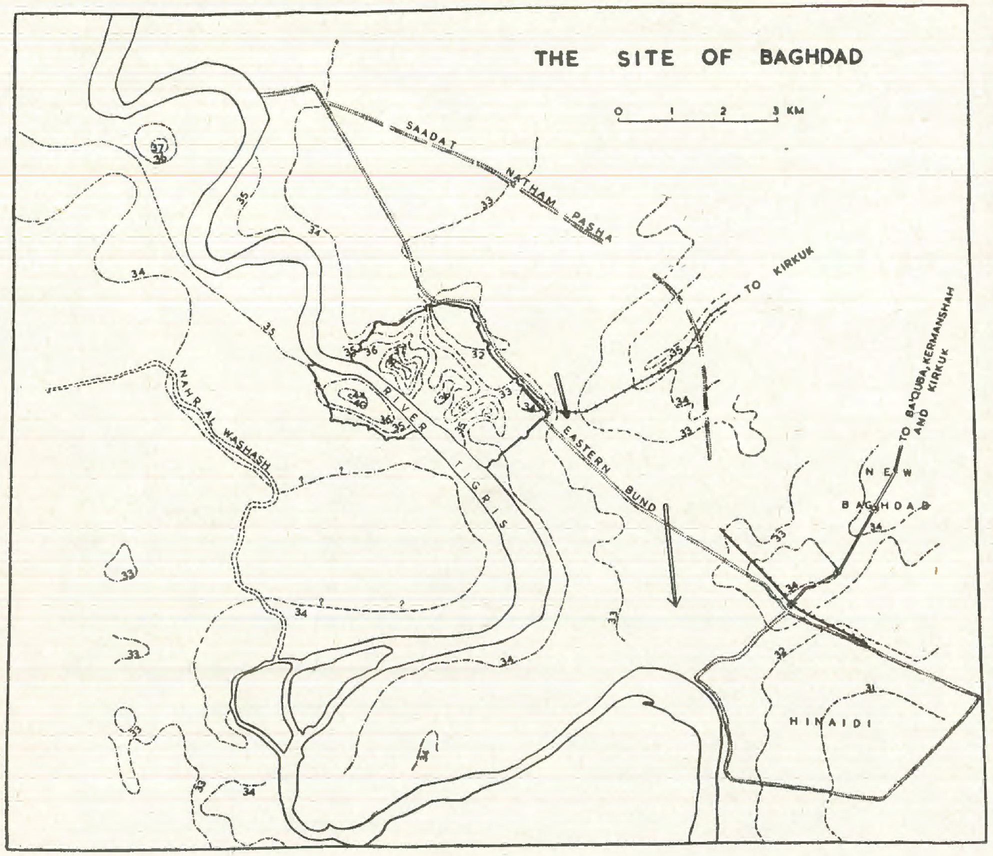

Fig. 1. The Site of Baghdad. The contours are drawn at intervals of one metre.

old moat, to ensure the safety of the *madinat* from released flood waters. But this was unnecessary at Karkh, and the site of the walls and moat was eventually used for streets.

Just before the First World War, Sir William Willcocks was asked to advise the Turkish Government on irrigation in Mesopotamia. He advocated the continuance of the old system to protect Baghdad. But

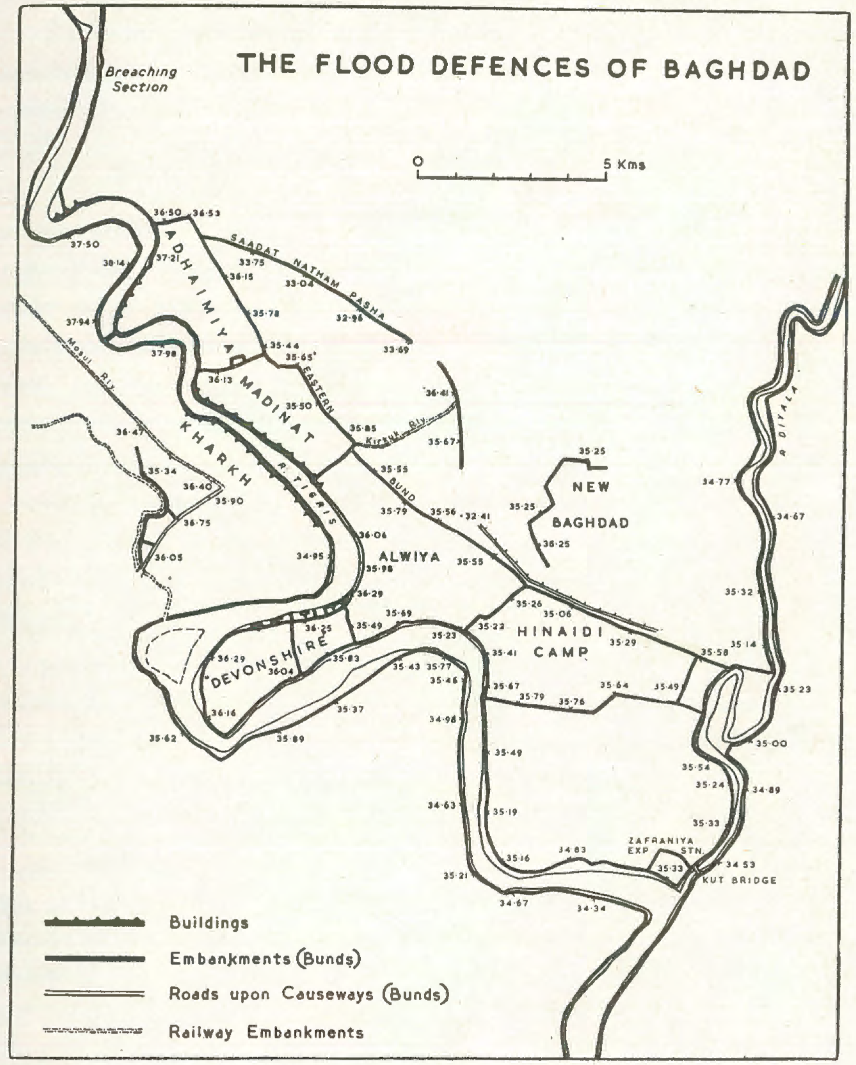

Fig. 2. The Flood Defences of Baghdad.

to enlarge the area on which it would be safe to build on the east bank, he suggested that a new bund should be constructed, from Muaddham to Jararah. He condemned the embankment begun by one of the last Turkish governors, Natham Pasha, which, starting north of Muad-

dham, sweeps eastwards and southwards in a semi-circle[1]. This work, the Saadat Natham Pasha, was undertaken in advance of precise levelling, and crosses the two natural promontories leading eastwards to the Diala fan. Thus the natural escape channel for flood water was blocked, and floods released at the breaching point upstream of the city could not flow freely southwards. The Saadat Natham Pasha was accordingly never completed, and gaps have been permitted to appear along the line of natural flow. After the British conquest of Mesopotamia, Willcocks' proposal was executed in a modified form and the results have lasted until today. From a point on the Saadat Natham Pasha north of Muaddham and about three-quarters of a mile from the river, a *bund* was aligned almost north-south. This, the Eastern Bund, met Midhat Pasha's bund near the north-eastern corner of the *madinat*. From near the south-eastern corner, the new embankment was continued along a slightly more easterly alignment as far as the Diala, thus protecting the new camp and aerodrome at Hinaidi, and the embryo civil cantonment at Alwiya[2]. Cross bunds were built north of Hinaidi and north of the *madinat*, so that the protected area is divided into five unequal compartments, of which the old city is one. More recently, two more bunds thrown across the Karrada isthmus serve to localise the effects of any small breach or overflow along the vulnerable curve just to the north. The value of these most recent works was demonstrated during the flood of May, 1950.

But these works, in the south, prevent flood waters reaching the river beyond the Karrada meander. Moreover, the Eastern Bund crosses the southern of the two promontories on the Diala fan. Flood waters tend to be ponded to the north. A drainage channel, accordingly, has been cut through this strip of slightly higher land, and the Ba'quba road carried across by a bridge. When the levee has been breached to the north of the city, water can flow all the way to the Diala. Thus the area to the east of the Bund is still liable to periodical inundation, and apart from the mud-huts and brick-works is unoccupied. Beyond

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[1] W. Willcocks, *The Irrigation of Mesopotamia*, 1915, p. 17.

[2] *Brief Note on Irrigation Works in Mesopotamia... up to 1918*, Baghdad, 1919.

the artificial channel, on the higher ground of the southern promontory, it has been considered safe to plan a suburb, New Baghdad, which has, however, been protected on its northern boundary by a subsidiary bund, designed to deflect flood water to the artificial channel. But few houses have as yet been erected; and would-be residents are inclined to await the assurance of greater security from floods which will be granted by the Tharthar scheme and the high dams on the Tigris tributaries, now being planned and built[1].

No such protective works have been required on the western bank. The flood defences are confined to the river wall, maintained to a height

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[1] *Report on the Control of the Rivers of Iraq and the Utilization of their Waters*, Directorate-General of Irrigation, Baghdad, 1951.

The exceptional floods of March, 1954, demonstrated the significance of these relief features and their relation to the existing methods of flood control. So high was the Tigris that when the main river bund was breached north of the city, the released waters quickly rose to the top of the Eastern Bund. The artificial channel between New Baghdad and the south-eastern corner of the city proper could not pass flood water fast enough to the south, even when New Baghdad was inundated and the Kirkuk railway embankment demolished by army engineers. Raising the height of the Eastern Bund by sandbags did not avert the danger, and at the crisis the embankments surrounding Hinaidi Camp were breached to permit water to flow more readily to the Diala confluence and beyond.

It may be at least surmised that the present alignment of the Eastern Bund, south of the *madinat*, is faulty, because the ancient depression leading to the Tigris just below Karrada is barred to flood water seeking an escape southwards, despite the artificial channel described in the text. Willcocks did not recommend the enclosure of the area occupied by Hinaidi Camp within the protective bund; but immediately after the First World War the circumstances in a disaffected country may have precluded an alternative plan. It is evident indeed that the priority which has been given to the Wadi Tharthar Scheme in the Iraq Development Plan is fully justified (*vide* J. H. G. Lebon, *The New Irrigation Era in Iraq, Economic Geography*, vol. XXXI [1955], pp. 47-59). Not only will Baghdad be relieved from recurrent peril, but agricultural lands will be saved from almost annual devastation. It has recently been announced that the barrage at Samarra has now been completed (*The Times*, London, 30th November, 1955). Also, the city will be free to expand eastwards of the Bund, and a firm of London town-planning consultants is at present engaged in preparing a report upon the future of the city.

preserving the plain from overflow to the level at which it is necessary to breach the *bund* and release excess water to the east. The first stretch of the Baghdad-Mosul railway, built by German engineers between

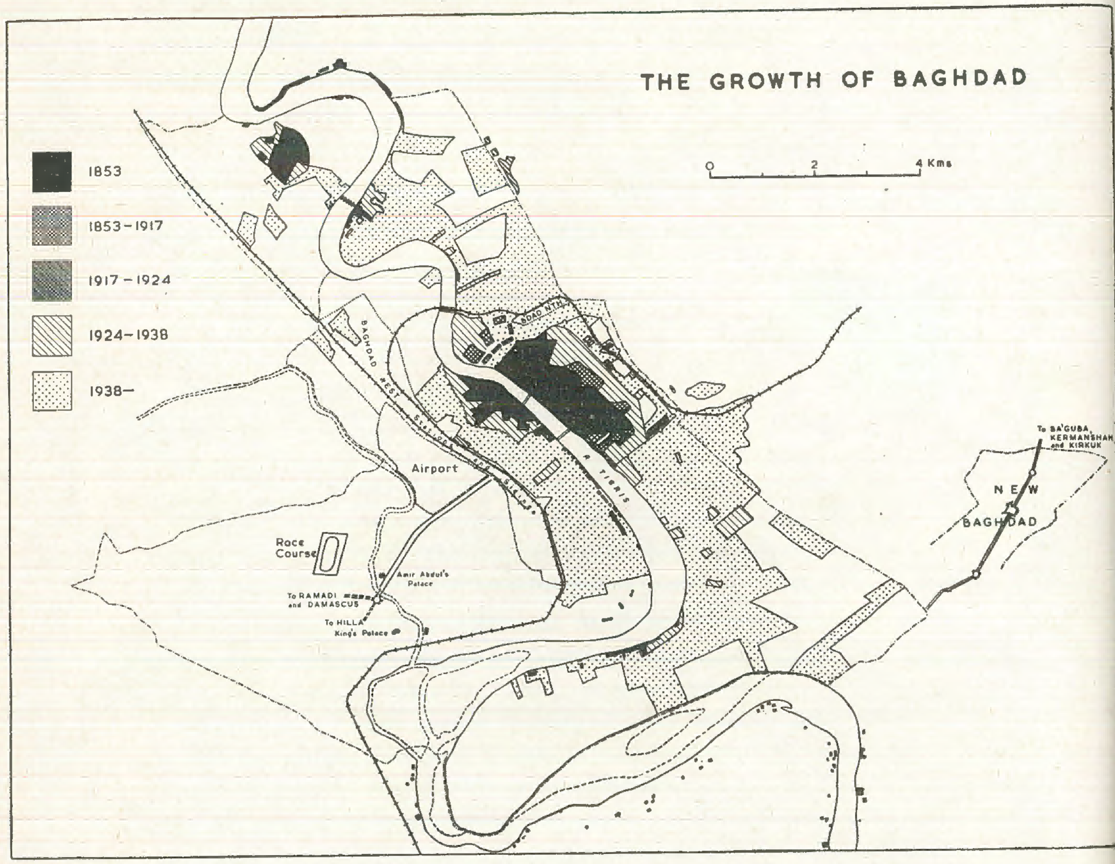

Fig. 3. The Growth of Baghdad.
The stippled area shows land that was used for building between 1938 and 1953.

1911 and 1914, was laid along a *bund*, perhaps because it was feared that severe floods might also breach the western levees. The main road from Karkh to Ramadi and Hilla, as far as the crossing of the Nahr Al Washash, is built upon a causeway. These two *bunds* could form part of a comprehensive scheme to encircle West Baghdad, but completion is unnecessary, because adequate protection can be assured by breach-

ing the eastern levees at the right time. To the west, therefore, Baghdad has the same freedom to expand as in the days of the Abbasids, and the latest maps accompanying this article disclose that actual and projected developments have in fact been more widespreading than to

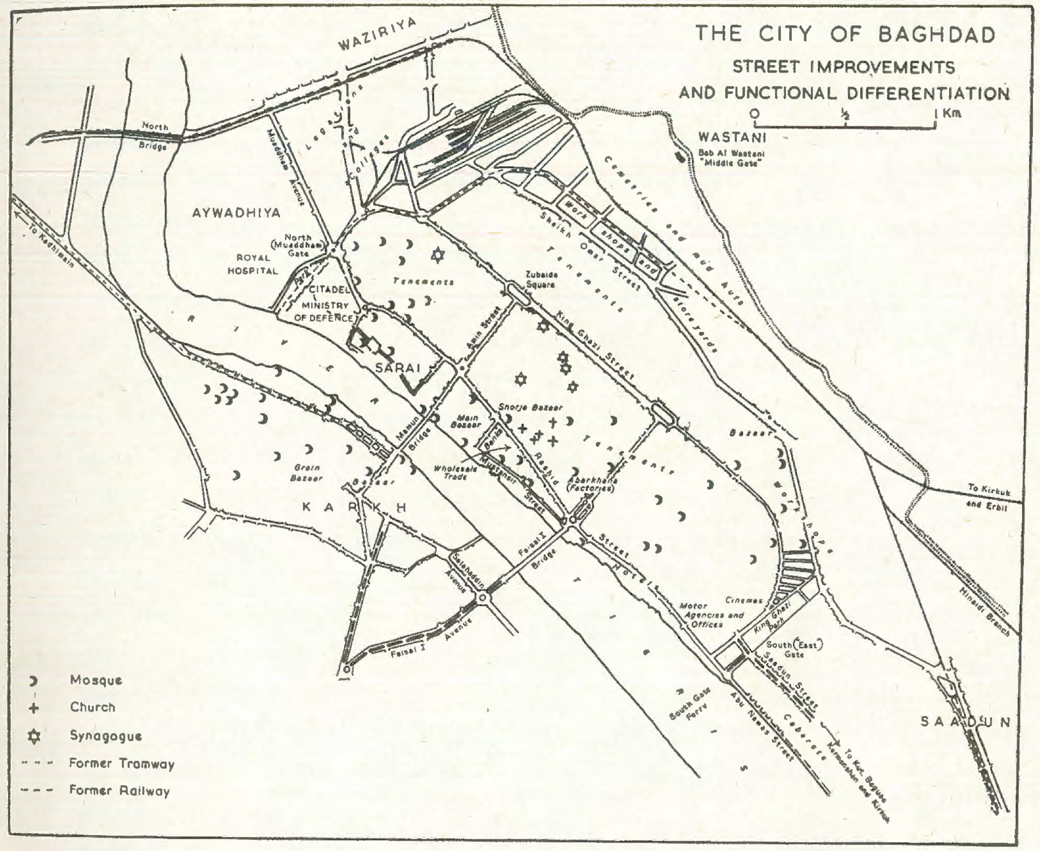

Fig. 4. The City of Baghdad : Street Improvements and Functional Differentiation.

the east. Urban features requiring large tracts of land, such as the airport, the main railway yards and the royal places, have all been located west of the river (Figs. 3 and 4). To have used lands for these purposes within the Eastern Bund would have left practically no space for other building. Beyond the railway yards, the streets of new suburbs have already been pegged out near the Race Course and the royal places.

TURKISH BAGHDAD

The Turkish city changed but little from the sixteenth to the end of the nineteenth century A.-D. Only about half the area enclosed by the wall was actually occupied by buildings (Figs. 3 and 5). The remainder was partly cultivated, and partly excavated for bricks, as is clearly shown on Burckhart's map (1766) and that of Felix Jones (1853). Exceptionally for a Muslim city, the cemeteries were intra-mural, perhaps because it was thought undesirable that floods should lave land consecrated to the departed. At the north-western corner was the fort, occupied by the garrison. Close by was the Sarai or governor's residence and seat of the civil administration. Immediately to the south, again, at the eastern bridgehead, was the chief seat of trade, in the bazaars of the Sarai, of Maidan, of Shorji and the present cloth bazaar, rebuilt and triply-vaulted in brick by the last of the Mameluke Pashas, Daoud, about 1830. When western merchants appeared in the eighteenth century, they established themselves just southwards of Daoud Pasha's new bazaar. Today, in Samawal Street (called Bank Street by the foreign community), leading to the river from the Mirjan Mosque, are the Baghdad offices of the British banks operating in Iraq; and close by are the offices of the older western mercantile firms, typified by Stephen Lynch and Company, founded by the pioneer of steamboat navigation on the Tigris more than a century ago.

Until only five years ago, the Jewish community numbered about half of the total population, and was dominant in commerce. Jewish homes, schools and synagogues occupied the quarter immediately to the east of the Sarai and the bazaars. A majority of Jews left Iraq for Israel in 1950-1951, and only one school now remains open. The number of synagogues has also been reduced. A smaller Christian quarter has been long-established just to the south. Within it are Armenian, Chaldaean, Nestorian and Latin cathedrals and schools. Thus within the walled city, Arabs lived to the north and to the south; but not at the centre. But Karkh was entirely Arab. Its bazaar was located

in the streets close to the bridge-head; and the remainder of the built-up area consisted of dwelling houses and mosques.

The characteristics of Levantine cities were strongly imprinted upon Turkish Baghdad. During this era, townsmen were accustomed to go about their business on foot. Goods were often carried on the backs of porters, and even today the Kurd, bowed down under the weight of grain sacks or even lengths of steel tubes, is a familiar sight in and near the bazaars. Travellers entering from afar, and a few wealthy residents, might ride on horses or asses. Vehicles were unknown. Narrow alleys thus sufficed for travel within the city. If two laden beasts could pass, no more could be required. The less the space occupied by streets, the more convenient it was for the *Baghdadis,* because the total occupied area was minimised, and distances required to be traversed were accordingly reduced. The occupied area, apart from the streets, was entirely covered by buildings. The dwelling houses which so greatly predominated were of the older Turkish type. To the street, only a well-studded main door and one or two very small barred windows are to be seen in the otherwise blank external wall of the ground floor. Above, there is commonly a protruding windowed balcony, which may almost meet the corresponding feature of the opposite house. Within, two storeys of rooms surround a quadrangular courtyard, large or small. The first-storey rooms are usually larger than those at ground level, and there is often a colonnade on one or more sides. The roof is flat, and is thickly plastered with a mixture of silt and chopped straw. On it, the family sleeps in summer whilst the interior gradually cools after the heat of the long day. Such houses and such an urban plan are well adapted to the climate as well as to the economic state of society. The streets and courtyards are shaded from direct sunlight except for brief midday hours. Cool air lingers after sunrise, especially in the shady corners of the courtyard, which may be further protected by a date-palm or by a vine trained over a pergola. The ground floor rooms, or a *sirdab,* i. e., a sub-basement provided with a ventilating shaft, are well insulated from exterior heated surfaces, and remain cool during the afternoon rest period. For generations, Baghdad has merited and received its nick-name of *Al-*

Zawra—the crooked—although this popular etymology may not be true.

Access to the walled city was originally provided by four gates. To the north, the road from Bab al Muaddham, known to the European community as North Gate, leads to the riverside village of Muaddham, opposite Khadimain. Near the north-eastern corner was the Bab al Wastani or Middle Gate. Farther southwards, in the eastern wall, was the Bab al Talism or Gate of the Talisman, which was walled up when Murad IV had re-entered through it into the city after finally hurling the Persians from Mesopotamia in 1638 [1]. By the nineteenth century, this gateway had fallen into ruin. Finally, in the south wall, stood the Bab As Sharqi, or Eastern Gate, known to the more precise-minded European community since 1917 as South Gate; but perpetuating, in Arabic, the memory that during the Abbasid period the Khorassan way left the city at this point. In Turkish times, a road issuing from the Bab As-Sharqi led to the Diala crossing and to Kut.

MODERN IMPROVEMENTS (1868-1935)

Modern street improvements, designed to permit vehicular traffic to penetrate the *madinat* and Karkh, date from the rule of Midhat Pasha; but works were spasmodic untill 1911. It was his intention to build boulevards along the demolished walls and to cut straight, wide streets through the built up-area. Of this he was able to achieve only a beginning. Of his boulevards, only a short stretch was laid on the edge of Karkh; of his interior streets, only small penetrations were effected in western Karkh and in the north of the *madinat,* where, along the line of the moat of the old castle, a street was laid giving access to the Sarai [2]. But at the same epoch, an imposing addition was made to the Sarai itself (now occupied by the Ministries of Finance and the Interior); and a small industrial district was founded just to the south of the Christian quarter, known as Abakhana. Herein are still concentrated tobacco factories and printing works. Here, also, the first electricity generating station was erected just before the First World War. Later, in 1888, a new street was cut in Karkh from the bridge-head north-westwards. On it, a tramway was laid, and horse-drawn coaches carried pilgrims to Khadimain until 1935 (Fig. 4).

[1] S. H. Longrigg, *op. cit.*, p. 74.

[2] Baghdad, as drawn by Rashid Khoja, General H. Q., Ottoman Army, A.-D. 1908, reproduced in Dr. Souza's *Atlas*, p. 16.

Just before the First World War, German engineers reached Baghdad, and began to build a railway to Mosul, to complete the connection between Berlin and Baghdad. Starting from a river pier just south of Karkh, and building a small station close by, they founded the nucleus of the now extensive railway yards and residential areas occupied by the railway staffs. At about the same time, the German advisers to the Turkish army emphasised the need for wider streets leading to the bridge, so that artillery could be moved to and from across the river. Accordingly, the demolitions necessary to complete a north-south road through the *madinat,* and a connection to the bridge, were begun. The completion was delayed until 1915. Then, as military government was proclaimed to meet the British threat from Basra, a gang of workmen demolished, overnight, the remaining houses blocking the new avenue. By the British, after their occupation had begun in 1917, the new road was called Main Street, and its connection to the river, Bridge Street. By the independent government of Iraq, these streets have been renamed Ar Rashid and Mamun Streets, after famous Abbasid rulers.

Two important new constructions accompanied the British occupation. A second boat bridge (the Maude Bridge) was thrown across the Tigris, from the southern extremity of Karkh to a point in the southern half of the *madinat*. Furthermore, to augment the flow of supplies from Basra, metre-gauge railway lines were laid from Basra to Karkh, and from Kut to Baghdad. The former line met the standard gauge Baghdad-Baiji (later Baghdad-Mosul) line at Baghdad West. The latter was brought within the *madinat* at its south-eastern corner and originally passed just east of the built-up area to a terminus close to the North Gate. (Figs. 3 and 4).

The ensuing period of the British Mandate (1920-1932) produced important extensions to the area occupied by buildings. Near the South Gate, houses were acquired or built in which new branches of administration, or messes or clubs were established. As a consequence, this

quarter is distinguishable today as a secondary seat of administration, and by the association of the chief hotels, a British Club, the central telegraph office [1], travel agencies, shops and offices of firms importing motors and spare parts, branches of western departmental stores and the largest concentration of cinemas in the city. In the east, the new railway line attracted contractors' yards and workshops, including small foundries. Today, a considerable number of workmen are engaged in repairing cars, lorries and pumping machinery, using imported machine tools and other equipment. Buildings have now covered nearly all the land between the edge of the Turkish city and the Eastern Bund (apart from the cemeteries). West of Karkh, a large tract of land was alienated to the railways, over which sidings, repair yards, warehouses, houses for the staff and hutments for the labourers slowly spread. As government became better consolidated, and prosperity increased, a distinct impetus was given to the building of private dwelling houses. New roads were pegged out within the *madinat*, close to South Gate, and also, just outside. Along these roads, houses were built in what, for lack of a better term, may be called the neo-Turkish style. The inner court-yard was abandoned in smaller houses, but preserved in the larger. Large windows were provided overlooking the street from the ground floor rooms, and windowed balconies, as in older Turkish houses, in first floor rooms. Gardens were still eschewed, and thus the newly-occupied land was as closely covered by bricks and mortar as the older quarters, except that the new streets were wide enough to permit horsed carriages or *arabanas*, which were now becoming common, to pass one another. But the regularity of the terraces and the straight streets suffices at a glance to distinguish these neo-Turkish houses from the older type of *Al Zawra* proper (see Figs. 5 and 6). Such terraces were also built in Karkh, mainly on land which had been enclosed by the old wall, but previously not built upon, in Khadimain, and in Muaddham.

[1] This occupied the site of the British Indian Post Office, established opposite the old British Residency, now the Customs Office. The origin of this «South Gate Quarter» may accordingly be traced to the appointment of C. J. Rich as the first British Resident to Baghdad in 1808.

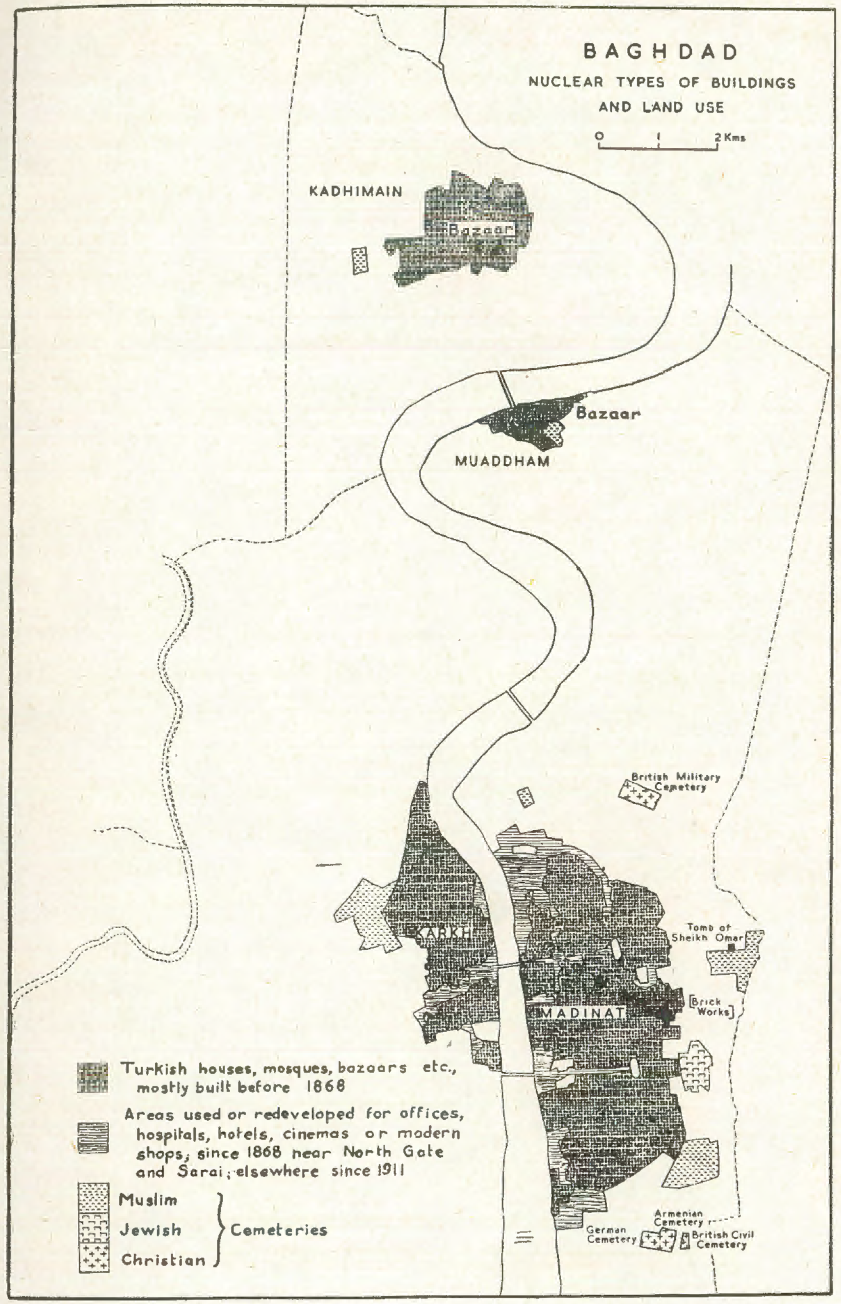

Fig. 5. Baghdad : Nuclear Types of Buildings and Land Use (1951).

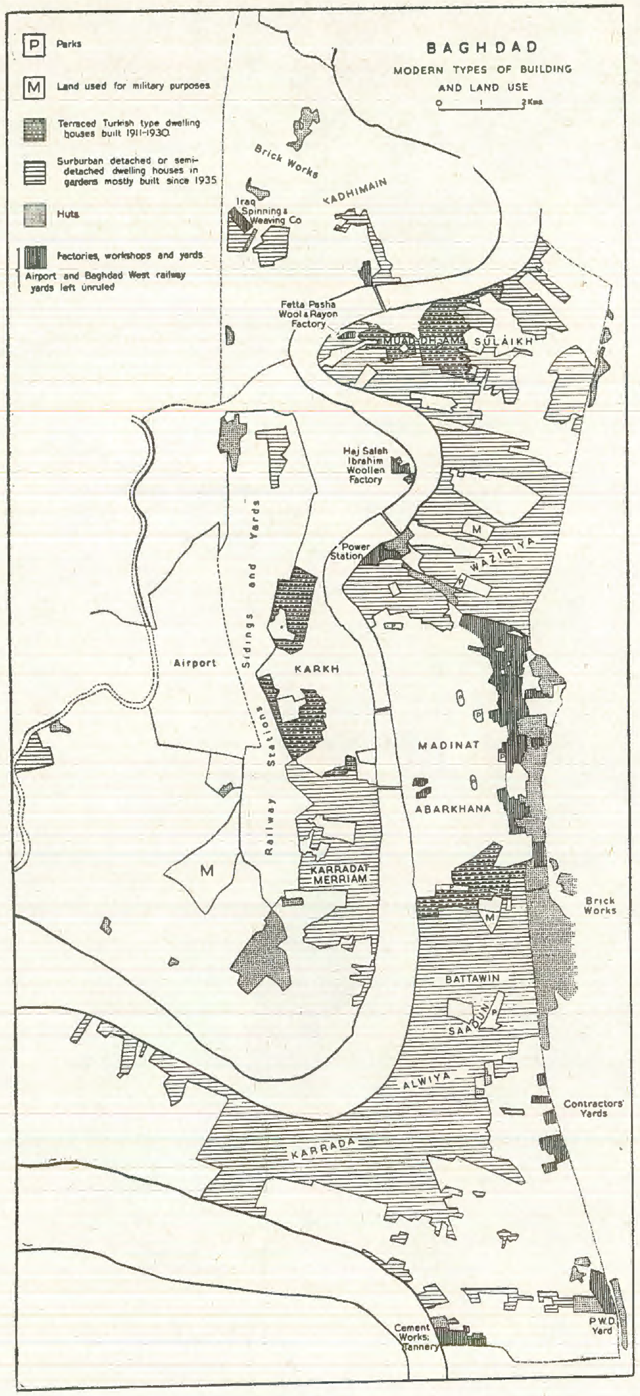

FIG. 6. Baghdad : Modern Types of Building and Land Use (1951).

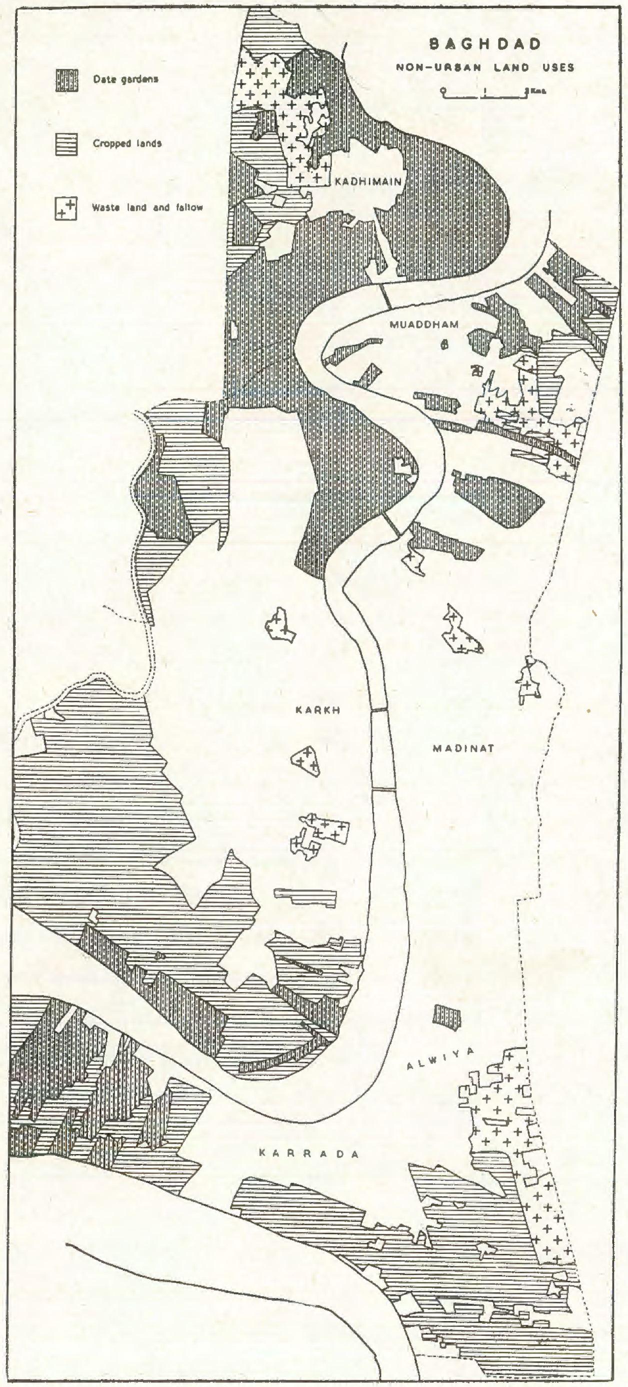

FIG. 7. Baghdad : Non-Urban Land Uses (1951).

MECHANICAL TRANSPORT AND THE SUBURBAN AREAS (1935)

Until the late' thirties, a true suburban zone had not appeared. The reason is not far to seek. Baghdad, until that date, lacked mechanised suburban transport. Neither rail, nor electric tram, nor omnibus had offered the means by which the working population could daily enter and leave the old city and Karkh. Moreover, apart from passenger ferries, mostly in rowboats, the river could be crossed only by the two boat bridges. Across these, transit was slow, for light vehicles, animals and pedestrians jostled each other into confusion and stoppages. But during this decade, street improvements, accompanying the introduction of private cars for the wealthier citizens, omnibuses and taxis, prepared Baghdad for the rapid suburbanisation of the last twenty years. Movement within Karkh, for vehicles, has been facilitated by cutting streets through the bazaar to the head of the Mamun bridge; and by completing the ring road planned by Midhat Pasha nearly a century ago. In the *madinat,* a relief road to Ar Rashid, known as the Sharia Al Ghazi (Ghazi Street) has been cut between South and North Gates. Connections have been hewn to the two bridges. Farther east, a third north-south road, known as Sheikh Omar, has been aligned in the midst of the workshop zone. At its northern end, this follows the bed of the original Kut-Baghdad railway, which has been diverted to the new and more extensive Baghdad North Station and sidings, now the terminus of the line to Erbil since the Kut line was torn up. At both North and South Gates, the zone of the moat and Midhat Pasha's bund have been used to improve the street plan and to plant small but well-conceived parks. At North Gate, also, on the line of the moat, have been sited the Amana Hall (owned by the Municipality), King Feisal Hall, the Head Office of the Omnibus Company and the College of Arts and Science. Thus at either end of the old city, Midhat Pasha's plans have eventually been realised. To the east, a boulevard has not been required along the old moat, for Sheikh Omar and parallel streets permit north-south vehicular movement, and in an unlovely zone of tenements, small workshops cemeteries, a railway station and clumps of mud-huts, the French

concept of the boulevard could not be more incongruous. The street improvements have been accompanied by permanent bridges, and the boat bridges were towed upstream, one to be moored between Khadhimain and Muaddham; the other to Samarra. The era of the motor car and omnibus had begun.

These improvements have not entirely converted a city built for pedestrians into one in which vehicles can circulate freely. Access to the *madinat* from the east as well as the south is by the South Gate, because the road to Ba'quba leaves the protected area at its extreme south-eastern corner, and not by the Bab al Wastani or Bab Al Talism. The relief roads to Ar Rashid through the eastern part of the *madinat* are not used to full capacity, because the concentration of commerce and administration close to the river causes traffic to converge to South and North Gates. Traffic for the west side must also pass along or cross Ar Rashid. Moreover, there are very few parking places within the *madinat,* and side streets are absent. Plans for another north-south avenue, midway between Ar Rashid and Ghazi Street, have been drawn; but works have not yet commenced. A proposed new bridge at South Gate, which may shortly be built, will certainly relieve congestion in the old town by relieving *Ar Rashid* of much traffic crossing the river; but the problem cannot be solved fully until land is made available for parking places.

As the suburbs were born, public taste changed, and detached houses in small gardens came to be preferred to the older Turkish type of house. The land which would have sufficed for three or four older houses is now occupied by one. Consequently, the built-up area has greatly expanded. The Second World War retarded this tendency for four or five years; but since about 1947, the rate of building has been phenomenal. Suburban extension has, by good foresight, been preceded by excellent street planning. The old town is connected with the periphery by broad, straight, boulevards, recently given concrete foundations and asphalt surfaces. Between dual carriage ways are strips of ground planted with trees, shrubs and flowers. At the intersections of main avenues are small circular gardens, and land has been reserved for larger parks elsewhere, of which the largest, Saadun Park, in the

midst of the wealthiest residential district, is now mature. As side streets are paved and as the zone loses its garish newness, the suburbs of Baghdad will compare favourably with the modern quarters of Beirut or Cairo. This movement to the suburbs has been most marked east of the river, and southwards rather than northwards. But west of the Tigris, many new houses have been built in Karradat Merriam, and the new road-railway bridge (the North Bridge), opened in 1952, is already stimulating house construction between Karkh and Khadimain.

ADMINISTRATIVE DIVISIONS AND POPULATION DISTRIBUTION

Administratively, Khadimain is still separated from Baghdad; but a union of the two municipalities is now being effected. At the end of the Turkish period, the authority of the municipality of Baghdad was limited to the old city and Karkh. During the mandate, the boundaries were extended to the Eastern Bund (excluding Hinaidi Camp), and westwards to the ancient canal known as the Nahr Al Washash. More recently (1948), the royal estates westwards of the Washash have been added; but little has been built so far from the city proper. The race course and the golf course have, however, been moved to this area from more restricted sites nearer the city, and streets have been pegged out to prepare land for the building of a new garden suburb.

At the last census (1947), the population of Baghdad Municipality was 466,733 and of Khadimain 48,676. The inhabitants of Greater Baghdad, therefore, numbered slightly more than half a million. The area within the Municipality is divided into 95 wards or *mahalets,* and Khadimain into 5 *mahalets,* making exactly 100 sub-divisions. In 1918, when a census was taken prior to the imposition of food rationing, the population of the old city (including Karkh) was 185,000 [1]. In 1947,

[1] R. Coke, *Baghdad : City of Peace,* 1927, p. 298. This author also quotes earlier estimates of the population; *viz.,* 80,000 in 1816 (Buckingham), 100,000 in 1831 (before the flood and plague of that year), 60,000 in 1841 (Baillie Fraser), and 180,000 in 1914. All these estimates exclude Khadimain.

This article has been revised from the text of a paper read to Section E (Geo-

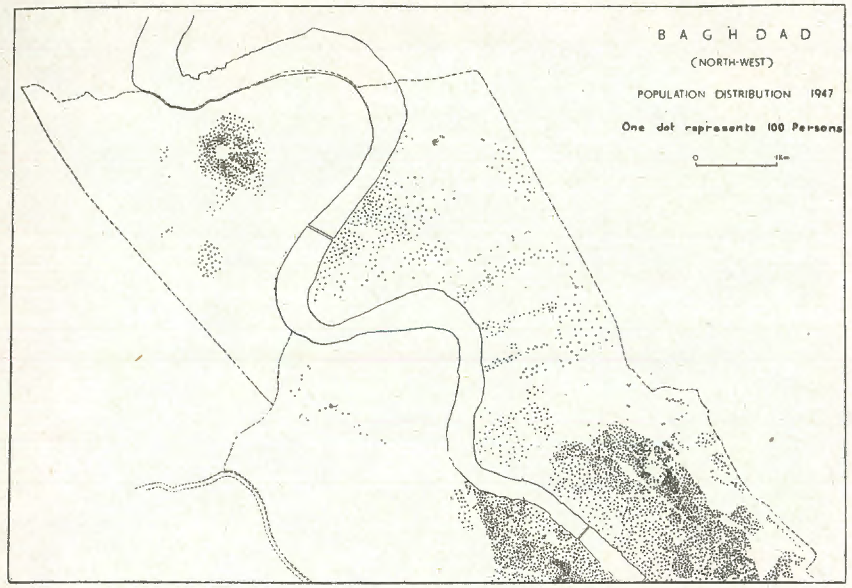

Fig. 8. Baghdad (North-West) : Population Distribution (1947).

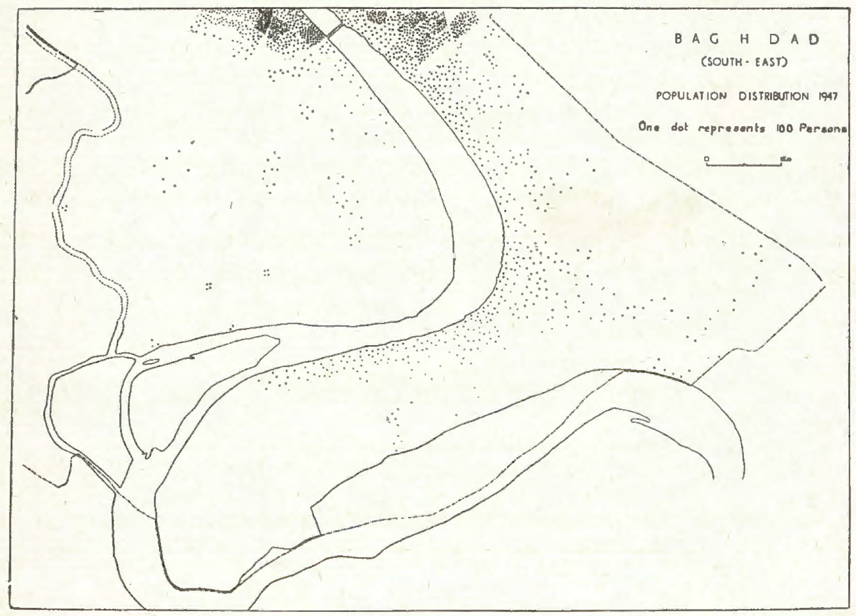

Fig. 9. Baghdad (South-East) : Population Distribution (1947).

it was 321,225. The population of the suburban areas (including Muaddham), was 145,508. Thus about a quarter of the population now lives in the suburbs (excluding the nucleus of Muaddham). In the past six years, the total population has increased very rapidly. Baghdad is now a magnet for the poor of the countryside, who camp in matting or mud huts in the many such aggregations scattered throughout the suburban districts and on the fringes of the built-up area, and support themselves by casual or unskilled labour. The rapid increase of the central government service, and the foundation of moderately large factories manufacturing textiles, cigarettes, beer, cement, leather, soap and vegetable oils, improvement of medical services and a pure water supply have all contributed to the increase of numbers.

The details of population distribution are revealed by a dot map (Fig. 8). Density is greatest in the old city and Karkh. In two *mahalets* of the *madinat,* and one in Karkh, the mean density exceeds 1000 persons per hectare, or 405 per acre. Where few buildings rise above a second storey, such a numerical density clearly betokens unhealthy overcrowding. The map also reveals a distinct inner zone in the *madinat,* curving eastwards and southwards from the North Gate, through the Jewish quarter to Bab As Sheikh, in which population is congested. Bab As Sheikh is notoriously the most overcrowded and poverty-stricken quarter of Baghdad. Within this zone of dense population, most houses are let as tenements. The line of the old fortifications is clearly a divide between dense urban and sparse suburban population. It must long remain as an urban frontier between the mediaeval and twentieth century districts of the capital.

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graphy) of the British Association for the Advancement of Science, Liverpool Meeting, September, 1953.

The author has pleasure in acknowledging the help and encouragement given by Dr. Ahmed Souza.

Photo 1.—Ar Rashid, looking north from the roof of the National Bank of Iraq, at the junction of Samawal Street.

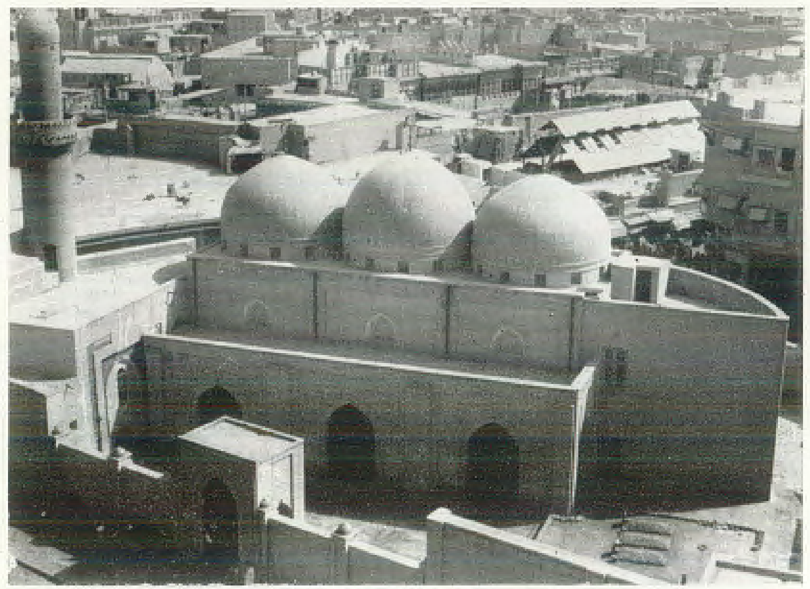

Photo 2.—The Mirjan Mosque, at the junction of Ar Rashid and Samawal Streets, from the National Bank, looking north-east. The western end of the Shorji Bazaar can be seen just to the right of the right-hand dome. Beyond is the former Jewish quarter.

Photo 3.—The River Tigris and Karkh, from the roof of the National Bank, looking south-west.
The large white building on the far bank is the British Embassy.
In the foreground, parallel with the river, is Mustansir Street, which was the only thoroughfare for vehicles before 1914.
The vacant land in the foreground was cleared for redevelopment in 1953.

Photo 4.—The Main Bazaars and the Sarai, looking north from the National Bank.
To the left is the Mamun Bridge, and immediately, in front of its eastern end is the elongated courtyard of the Mustansiriya.

Photo 5.—The Bab al Wastani, or Middle Gate.
Only a small fragment of the second round bastion has survived, to the left of the gateways.

Photo 6.—The Eastern Bund, looking south from near the north-eastern corner of the Old City.
The Bund is to the left, and its course is shown by the line of pylons. The depression to the right (west) is the old moat, now occupied by the matting huts of poorer folk. The steep slope immediately beyond corresponds with the line of the old wall, against which the accumulations of the Muslim cemetery were piled from the inside.

Photo 7.—A Boulevard in Waziriyah (a northern suburb), looking north from the College of Arts and Science, at the edge of the Old City. The building to the right is the College of Engineering.

Photo 8.—The Boat Bridge connecting Muaddham and Khadhimain.

Photo 9.—The North Bridge, opened in 1952, and carrying both a road and a railway track.
The track to the left follows one of the cross bunds shown on fig. 2.

L'ÉVOLUTION QUATERNAIRE
DES CÔTES DE CYRÉNAÏQUE

PAR

JEAN DEMANGEOT

Le paysage des côtes septentrionales de Cyrénaïque est, au printemps, magnifiquement coloré. Les flancs roussâtres du Gebel Akhdar sont piquetés de génévriers ; la mer, d'un bleu grec, devient opaline au pied des falaises toute blanches ; le vert tendre des prairies littorales est constellé de fleurs d'or ; la terre est rouge, pourpre et rose. Il y a même tellement de rouge que le morphologue soupçonne aussitôt une histoire quaternaire intéressante.....

De fait les incisions avales des ouadis montrent de belles coupes de remblaiement continental récent, dépôts dont l'interprétation permet à la fois de mieux comprendre la morphologie locale actuelle et de tenter des corrélations avec d'autres côtes de la Méditerranée.

Les observations qui suivent ont été faites en une dizaine de points entre Apollonia et Derna, plus exactement de part et d'autre de Ras el Hillal, sur un secteur côtier d'une quinzaine de kilomètres.

I. LA SUCCESSION DES ÉVÉNEMENTS QUATERNAIRES.

Entre l'escarpement de faille du Gebel et la mer existent trois gradins qui ont été récemment signalés et interprétés comme autant de plateformes d'abrasion marine [1]. Je n'ai pas examiné le gradin de 50-55 m. mais pour le gradin moyen (30 m.) et le gradin inférieur (15 m.) il n'y a pas de doute sur leur nature cyclique.

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[1] Cf. Montet (A.), *Les terrasses marines de la côte nord de Cyrénaïque, C. R. somm. Soc. Géol. France,* 7 novembre 1955, p. 256-258.

Si le gradin moyen est carié et lapiazé, le gradin inférieur, fossilisé sous un remblaiement, est en excellent état. La roche en place A (voir figure 1) est un calcaire blanc bien lité, à miches de silex, probablement

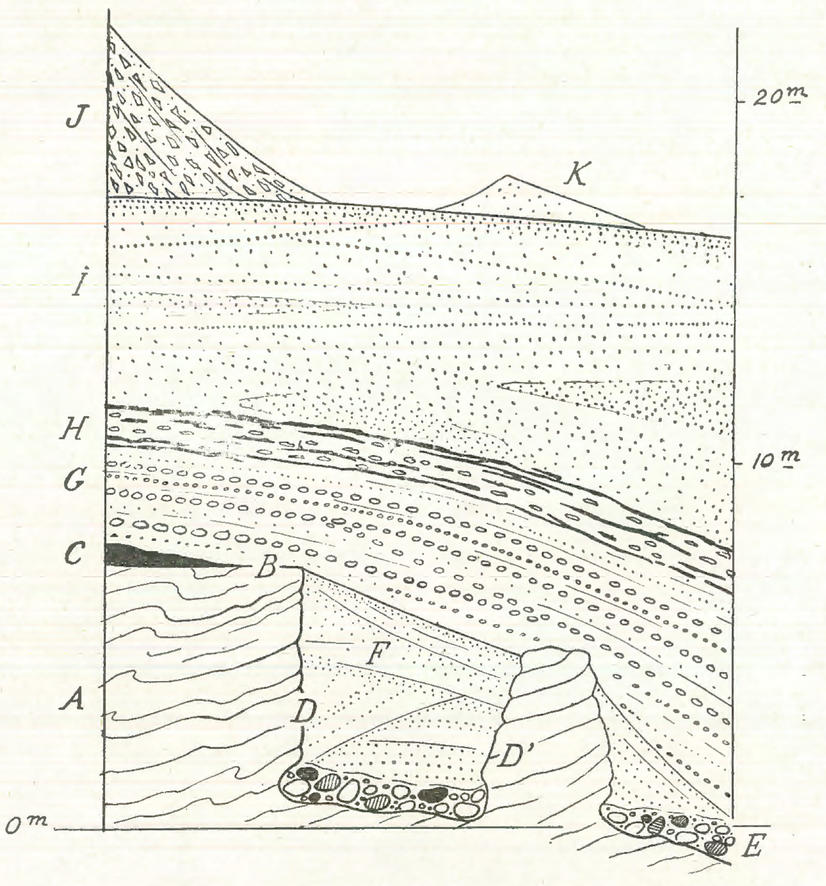

Fig. 1 Coupe schématique du littoral de Cyrénaïque, à l'est de Ras el Hillal. Les lettres renvoient au texte. Noter le rivage ancien DD' fossilisé sous le remplissage F, G, etc...

éocène [1]; elle est nettement tranchée par une surface d'érosion B probablement due à une *transgression marine*.

[1] Cf. Desio (A.), *Schizzo geologico della Libia,* note illustrative, C. N. R. S., Firenze 1933, 24 p., I carte h.-t. 1 : 4.000.000.

Cette surface, qui n'est pas absolument horizontale mais très légèrement gondolée, est empâtée, et préférablement, semble-t-il, dans les creux, par des plaques d'un conglomérat C identique à celui que l'on a décrit en Italie sous le nom de «mortadelle» [1]. Les gros éléments sont des cailloux tantôt roulés tantôt à angles vifs, jamais classés, de diamètre extrêmement variable (de 0,5 à 100 cm.); le ciment, de rose à rouge pâle, est fin et dur; il n'y a pas de fossiles visibles à l'œil nu. Cette mortadelle est une nappe continentale, contemporaine d'une *régression marine* et postérieurement rubéfiée [2].

On constate ensuite que la plateforme B a été ultérieurement tranchée en une falaise D et même façonnée en îlots D' par une *transgression marine*. Si le moindre doute pouvait subsister quant à l'origine de ces formes, il suffirait de regarder le conglomérat de galets, de sables grossiers et de bivalves brisés E qui ravine, vers + 1 m., la base de la falaise. A noter que dans cette plage E certains galets sont faits de mortadelle C et que certains autres sont percés par les Lithodomes.

Les traces de cet épisode marin sont désormais ensevelies sous un épais manteau d'origine continentale. Le remblaiement commence par un grès dunaire beige F appuyé contre la falaise fossile; ce matériel éolien dans lequel on trouve de nombreux Hélices, démontre l'existence d'une large grève émergée, donc d'une *régression marine*.

Puis, pardessus (et seulement au droit des vallées qui débouchent du Gebel?) des dépôts torrentiels discordants G faits de galets mal arrondis, de graviers et de sables roux, parfaitement classés et calibrés. Par endroits cette masse imposante, d'une dizaine de mètres d'épaisseur, est sensiblement rubéfiée.

Ensuite l'horizon supérieur H de ce cailloutis devient terreux, rougeâtre et entrelardé de croûte stalagmitique; parfois il se présente comme une vraie mortadelle mais avec un ciment sombre et vacuolaire.

[1] Cf. Demangeot (J.) in *Symposium sur les brèches quaternaires, Actes IVe Congrès internat. Quaternaire, INQUA,* Rome-Pise, 1953.

[2] Mais dans ce cas la plateforme ne pourrait elle être une surface pédimentaire développée par les ouadis divagants à la sortie du Gebel? Bien que l'hypothèse de l'abrasion marine soit plus simple l'absence (ou, du moins, la non observation) de dépôts marins est gênante.

Enfin, mais sans que le contact avec la croûte H soit toujours facile à observer, un grès continental rouge sombre I, épais de 1 à 10 m., couronne le tout : il contient des Hélices et j'ai trouvé en surface des éclats de silex retouchés, malheureusement peu caractéristiques. Cette espèce de diluvium éolien [1] prouve, lui aussi, que le rivage était assez éloigné.

L'ensemble plateforme-remblaiement fut finalement recouvert du côté de la montagne par des cônes d'éboulis non classés à éléments très anguleux J, et du côté de la mer, aux endroits les plus bas, par des sables dunaires, assez rares à la vérité.

Le dernier épisode de cette évolution est la *transgression marine* récente qui, amenant la mer au niveau O, détermina la démolition et le recul de la côte dont elle permit, en même temps, d'analyser la structure intime.

II. ESSAI DE CHRONOLOGIE.

La datation d'ensemble des événements que ces coupes permettent de dépister est relativement facile. Le point de repère chronologique essentiel est évidemment la plage transgressive E car, dans l'état actuel de nos connaissances sur la Méditerranée, une plage marine peu suspendue et surmontée de dépôts continentaux ne peut être que *tyrrhénienne.* Aucun argument défavorable ne saurait d'ailleurs être tiré de l'altitude même du gisement puisque celui-ci, dès l'origine, tapissait une topographie déjà différenciée [2]. A fortiori sur une côte comme celle de la Cyrénaïque soumise à des mouvements tectoniques très récents. On sait par exemple qu'une partie des ruines grecques d'Apollonia est actuellement immergée sous 4 m. d'eau; et à Bardia la submersion récente de la côte atteindrait 20 m. [3]. D'ailleurs en Tri-

[1] A. Montet (*loc. cit.*) signale un grès rouge marin à Foraminifères. S'agit-il de nos grès I? S'il s'agit du même dépôt la présence de Foraminifères n'infirme pas le caractère éolien de la formation car le vent n'arrache pas aux plages que des grains de sable.

[2] Cf. Gobert, cité par Balout (L.), in *Préhistoire de l'Afrique du Nord,* Paris, 1955, p. 39.

[3] Cf. Desio (A.), *Studi morfologici sulla Libia orientale,* vol. 2 de la Missione della R. Acc. d'Italia a Cufra, Rome, 1939, p. 53.

politaine la plage tyrrhénienne peut se trouver à + 36 m. comme à − 42 m. d'altitude.... [1].

Par conséquent, si la plage E est bien tyrrhénienne, la plateforme B, que nous admettrons d'abrasion marine, ne peut être que *sicilienne,* et la mortadelle C correspondrait à la régression «risienne». Inversement tout le remplissage ultérieur correspondrait à la *régression grimaldienne* (= Würm.)

Mais par la comparaison avec les coupes décrites ailleurs en Méditerranée on peut arriver à de meilleurs résultats. On constate ainsi de nombreuses ressemblances avec la coupe type d'Afrique du Nord [2] spécialement celle du Cap Blanc [3], et les coupes de Tripolitaine [4]. Avec la Palestine [5] comme avec l'Italie [6] la parenté existe mais elle est moins nette : là chaque interstade a provoqué une petite transgression que n'a pas enregistrée la côte de Cyrénaïque. Il est bien possible que l'enfoncement progressif de la côte ait, ici, noyé les traces de ces récurrences marines de faible amplitude.

La datation couche par couche est évidemment délicate à établir. Certes il n'y a pas grande audace à assimiler notre diluvium rouge [7] au diluvium à industrie atérienne d'Afrique du Nord, daté du Würm 2

[1] Cf. Lipparini (T.), *Tettonica e geomorfologia della Tripolitania, Bol. Soc. Geol. Ital.,* 1940, p. 255.

[2] Cf. Balout, *loc. cit.,* p. 42.

[3] Cf. Castany (G.), *Le Tyrrhénien de la région de Bizerte, Bull. Soc. Sciences, Nat.* Tunisie, 1952-1953, p. 171.

[4] Cf. Lipparini, *loc. cit.,* p. 256.

[5] Cf. Pfannenstiel (M.), *Das Quartär der Levante,* 1re partie, in *Abh. Math. Naturwiss. Klasse, Ak. der Wiss. u. Litteratur,* Mayence, 1952, n° 7, p. 464-466.

[6] Cf. Blanc (A. C.), *Variazioni climatiche e oscillazioni della linea di riva nel Mediterraneo centrale durante l'Era glaciale, Geol. d. Meere u. Binnengewässer,* t. 5, fasc. 2, 1942, p. 179-199.

[7] «..le manteau rouge, comme le ferait un loess, constitue un glacis adossé aux reliefs du littoral, recouvrant tout et plongeant sous la mer actuelle». Cette description de Balout (*loc. cit.,* p. 322) s'applique exactement au secteur littoral étudié ici. Ailleurs l'A. insiste avec raison sur l'extrême diffusion de ce glacis sur les bords de la Méditerranée.

par Balout [1] en accord avec Caton-Thomson. Je suis également persuadé du synchronisme avec les dunes rubéfiées à industrie moustérienne du littoral occidental de l'Italie : or à Palinuro (province de Salerne) ceux-ci sont attribués à l'épi Würm 2 [2]. Par voie de conséquence cela daterait la régression marine à climat steppique [3] responsable de la terre rouge G d'origine éolienne de la grotte Romanelli (province de Lecce).

Il est également aisé de synchroniser la dune à Hélix F avec la « dune 2 à Hélix » de Tunisie [4], le « grès dunaire » de Tripolitaine [5], et la première formation dunaire post-tyrrhénienne de Palestine. Or celle-ci serait de la grande régression Würm 1 [6], ce qui date approximativement la pierraille 1 de la grotte Romanelli. Il est d'ailleurs logique de placer cet épisode éolien dans la phase adcontinentale de la régression [7] ; mais c'est indémontrable pour l'instant.

Le troisième élément datable du remplissage est alors la croûte stalagmitique H, assimilable à la croûte « tropicale » d'Afrique du Nord ; bien qu'on sache peu de chose sur la signification des évaporites, il paraît raisonnable de placer cette croûte au moment du réchauffement interstadiaire Würm 1-Würm 2. Ce qui permet peut-être de dater la stalagmite H de la grotte Romanelli.

Enfin je synchroniserais volontiers les éboulis J avec le dernier stade frais du Würmien c'est-à-dire (et ici encore il faut écrire : peut-être) avec la pierraille A-D de la grotte Romanelli. Quant aux dunes récentes consolidées, presque inexistantes dans le secteur rocheux que nous étudions, elles sont probablement épiglaciaires c'est-à-dire versiliennes.

Une conséquence inattendue — mais inéluctable — de cette chronologie est de placer le cailloutis G dans la phase adocéanique de l'inter-

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[1] Cf. Balout, *loc. cit.*, p. 46.

[2] Cf. Blanc (A. C.), *Excursion dans les Abruzzes, les Pouilles et sur la côte de Salerno IV^e Congrès international Quaternaire, INQUA,* 1953, p. 78.

[3] Cf. Blanc (G. A.), *Excursion dans les Abruzzes,* etc. *INQUA,* 1953, p. 38-40.

[4] Cf. Castany (G.), *loc. cit.*

[5] Cf. Lipparini (T.), *loc. cit.*

[6] Cf. Pfannenstiel (M.), *loc. cit.,* p. 457.

[7] Cf. Tongiorgi (E.), *Le epoche glaciali dal punto di vista paleoclimatologico, Problemi attuali di Scienza e di Cultura,* fasc. 16, Acc. Naz. Lincei, 1950.

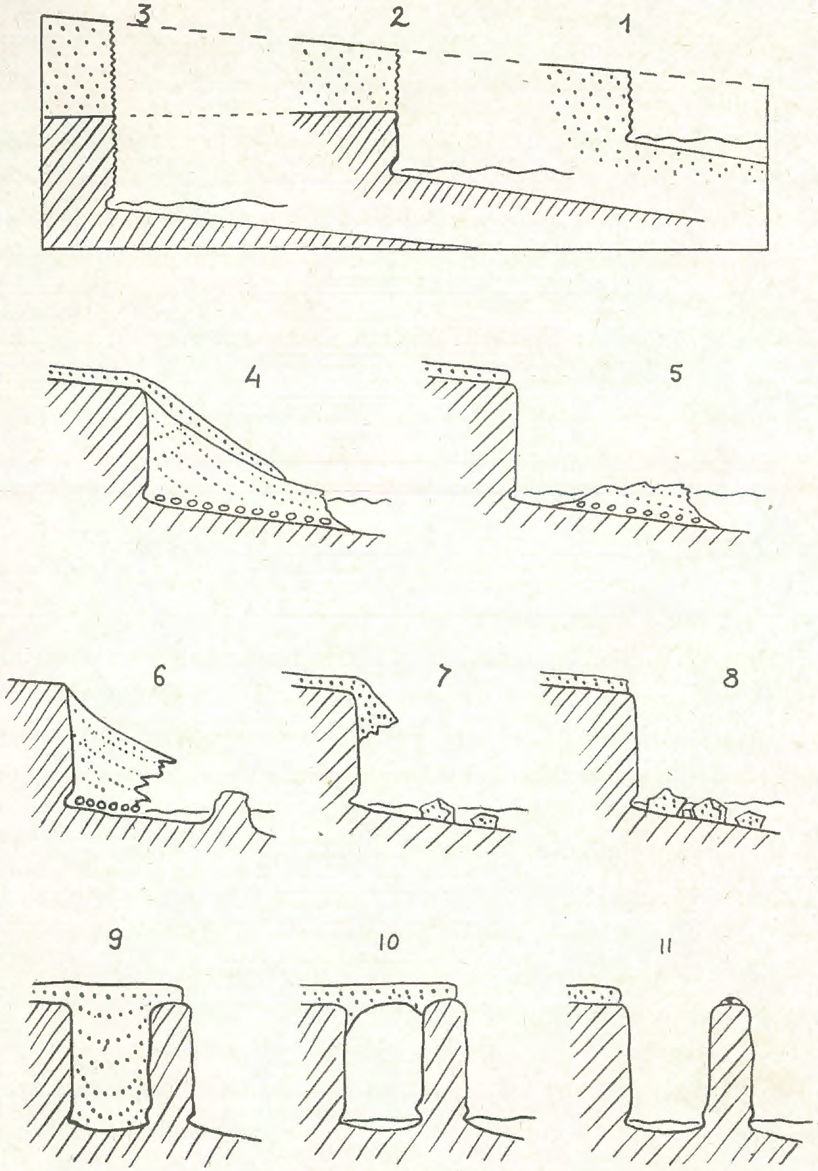


Fig. 2. En haut *évolution du littoral :* 1) la mer n'érode que le remplissage continental ; 2) l'érosion a atteint l'ancienne falaise tyrrhénienne, qui est exhumée ; 3) l'érosion a dépassé l'ancienne falaise et mord à vif dans la roche en place. *Exemples de formes observées sur la côte ;* 4) la mer taille une petite falaise dans le grès dunaire ancien ; 5) la falaise exhumée est surmontée de croûte, le grès dunaire ancien émerge en récif ; 6) grotte dans le grès dunaire ancien et îlot exhumé ; 7) un paquet de croûte reste appliqué sur la falaise ancienne en voie d'exhumation et forme un surplomb ; 8) la falaise ancienne est nettement nettoyée, mais sa base est cuirassée de blocs éboulés (cas très banal) ; 9) un chenal ancien rempli de croûte ou de diluvium ; 10) le même en voie de dégagement, la mer laissant subsister encore une arche de remplissage ; 11) le chenal est complètement désobstrué, l'île ou la presqu'île complètement dégagée.

stade Würm 1-Würm 2. Climatiquement rien ne s'oppose à ce que de vastes cônes de déjections aient recouvert la plaine littorale à cette époque. Mais puisqu'on sait que la Tyrrhénien a été déformé, ne pourrait-on pas y voir, plutôt qu'un effet climatique, l'indice d'une saccade tectonique du Gebel?

Partant d'une base assurée, la plage marine tyrrhénienne, le tableau chronologique présenté dans le cadre de cette note est probablement valable dans son ensemble : mais il est évident que chaque corrélation implique une hypothèse et soulève un problème.

III. CONCLUSION : LES FORMES ACTUELLES.

Vu du large ce secteur côtier de la Cyrénaïque paraît tout simple : une côte à falaise en somme. Vu de près il se révèle étonnamment divers. Il y a là une variété morphologique qui tient à la fois aux inégalités de la structure quaternaire et aux inégalités de l'attaque marine actuelle, celle-ci dépendant probablement des inégalités de l'affaissement post-tyrrhénien du socle. Plusieurs cas sont à envisager (voir figure 2).

1° La mer n'attaque encore que le remplissage continental et le rivage n'est pas encore parvenu à la falaise fossile D. On a des écueils, des îlots, des grottes et des vasques affouillés dans les grès rouges, le cailloutis ou la dune inférieure. La tonalité d'ensemble est sombre, le littoral ciselé plutôt que sculpté.

2° Le zéro actuel coïncidant fortuitement avec le zéro tyrrhénien, la mer a déblayé le rembourrage continental et atteint l'ancienne falaise D qu'elle lèche sans la ronger encore (côte « épigénique» des auteurs). On observe alors de haut en bas la tranche rougeâtre et grumeleuse des dépôts grimaldiens, la surface blanche et émoussée de la falaise exhumée, les blocs de matériel rouge effondrés au pied de l'abrupt. Parfois un paquet de grès reste collé sur la paroi mal nettoyée. Parfois, et le cas est aussi émouvant que pittoresque, les détails du rivage fossile — rias, îlots et détroits — démoulés par la mer actuelle, reparaissent après 180.000 ans d'ensevelissement dans leur fraîcheur retrouvée.

3° L'érosion a dépassé l'ancien rivage fossile et les vagues mordent en plein dans la roche en place. La tranche de la falaise, ultra-vive, est

ESSAI DE TABLEAU SYNCHRONIQUE DES DÉPÔTS LITTORAUX POST-TYRRHÉNIENS EN MÉDITERRANÉE. *D'après ouvrages cités de :* (1) L. Balout; (2) G. Castany; (3) T. Lipparini; (4) M. Pfannenstiel; (5) A. C. Blanc; (6) G. A. Blanc — En Italie P = marais pontins, V = Versilia (Toscane maritime) — La Grotte Romanelli est dans les Pouilles, Palinuro dans la province de Salerne.

AFRIQUE DU NORD (1)	CAP BLANC. (2)	TRIPOLITAINE. (3)	**CYRÉNAÏQUE.**	PALESTINE. (4)	ITALIE. (5)	GROTTE ROMANELLI (6)	
Grès dunaire supérieur.	Dune.	Dune.	Dune supérieure.	Dune récente.	P : dune rouge A.	—	
—	—	—	Eboulis J.	—	—	Pierraille A-D avec *Alca*.	Régression *Würm 3*
—	—	—	—	—	V : Tourbe C à *Abies*.	Terre brune E.	
—	—	—	—	Dune jaune 3e génération.	P : sables rouges et jaunes	—	Transgression
—	—	—	—	Couche marine B.	V : couche à *Purpura Hem.*	Stalagmite F?	
diluvium rouge à ind. atérienne	sables rouges 4 à silex atériens	terre argilo-sableuse rouge	diluvium rouge I à ind.	dune jaune-rouge 2e génération	P : sables C_1 dune de Palinuro	Terre rouge G à Paléolithique	Régression *Würm 2*
—	—	—	—	Oberer Geröll-horizont.	P : sables } *Abies* V : tourbe } *Abies*	—	
Croûte « tropicale ».	Croûte zonaire 3	—	Croûte H.	—	—	Stalagmite H.	Transgression (Tyrrhénien II?)
Lumachelle à Pectunculus	—	—	Cailloutis G.	Couche marine C.	V : couche marine à *Vitis*.	—	
Grès dunaire inférieur.	Dune 2 à *Helix*	Grès dunaire.	Grès dunaire à *Helix* F.	Dunes rouges 1re génération.	—	Pierraille I?	Régression *Würm 1*
—	—	—	—	Unterer Geröll-horizont.	P : tourbe à *Abies* D?	—	
—	—	—	—	—	P : tourbe à *Vitis* et *Quercus* E.	—	
Plage.	Plage à galets	Plage.	Plage E.	Plage à Strombes.	Plage à Strombes F.	Plage à Strombes K.	Transgression tyrrhénienne

encore rouge et blanche mais le tracé en plan plus simple et plus ample. Correspondant à un recul important du rivage la falaise peut approcher assez près du Gebel et entailler ainsi les éboulis du Würm 3. Dans ce cas l'escarpement devient grandiose (30 à 50 m.).

Nous remarquerons pour conclure que, à tous les stades, les galets, graviers et grains de sable de la plage actuelle sont du matériel fossile emprunté aux dépôts quaternaires et à peine remanié par les vagues.

Jusque dans ses détails cette côte «récente» comporte donc des éléments «anciens».

(Cliché J. Demangeot)

Photo 1. Coupe naturelle à l'Est de Ras el Hillal.— A gauche la falaise tyrrhénienne exhumée D. Au fond le remplissage de grès dunaire F et de cailloutis G. Au ras de la plage actuelle et derrière le bois flotté on voit clairement la plage tyrrhénienne E.

(Cliché J. Demangeot)

Photo 2. Un chenal fossile. — Ce chenal, intermédiaire entre la ria et la calanque, a été creusé à l'époque tyrrhénienne puis comblé par un remplissage continental. Le remplissage, qui a été en majeure partie exporté, subsiste encore en plaques à droite et à gauche. Derrière le photographe la calanque était encore obstruée.

(Cliché J. Demangeot)

Photo 3. Le trottoir littoral. — On voit clairement la plateforme d'abrasion B recouverte ici de cailloutis G et de croûte H. Au milieu la falaise tyrrhénienne est en voie de démoulage : observer la croûte surplombante, le paquet de grès dunaire ancien F au pied de la falaise (coupé par l'ombre), à droite la croûte qui descend dans le lit de l'ouadi. Au fond et à droite le Gebel Akhdar, faillé.

(Cliché J. Demangeot)

Photo 4. Le remplissage de diluvium rouge. — Ici la plateforme d'abrasion est recouverte directement par le diluvium rouge I. La plage noire à peine émergée correspond aux grès dunaire ancien F. A droite une île tyrrhénienne blanche D' commence à être dégagée de sa gangue de diluvium sombre

LANDFORMS AND PLANT COVER IN THE OMDURMAN DÉSERT, SUDAN

BY

M. KASSAS

UNIVERSITY COLLEGE, KHARTOUM, SUDAN

PREFACE

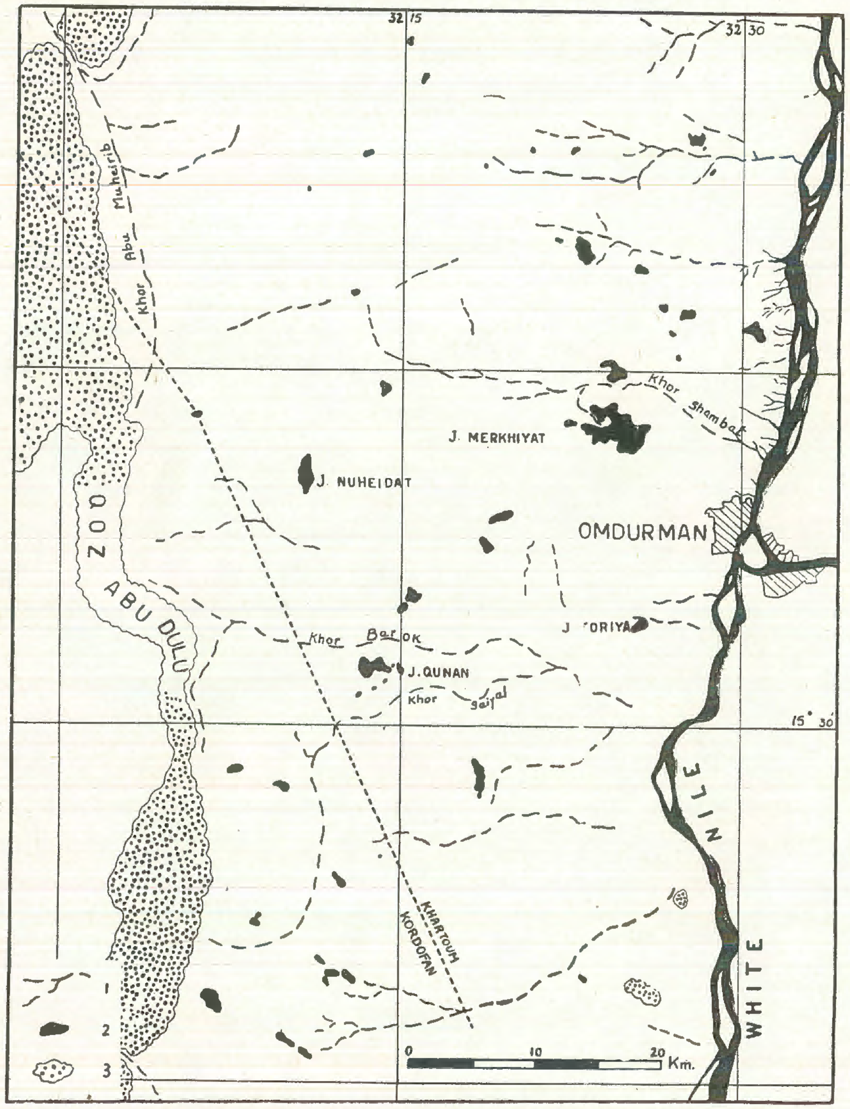
This paper reports on a survey of the plant cover in the arid country west of Omdurman, Sudan. The area of this study is about 4400 sq. km. (*c.* 1700 sq. miles), extending between lat. 15°15′ N. and lat. 16°00′ N. with the River Nile (*c.* long. 32°30′) as its eastern boundary and *Qoz Abu Dulu* (*c.* long. 32°00′) as its western boundary (see map). The study was carried out during two years : August 1953-September 1955 which included three rainy seasons. Frequent excursions were made possible by funds to cover transport expenses granted by the University College, Khartoum. Samples of plants referred to in this paper are deposited in the Herbaria of the University College, Khartoum; and the Faculty of Science, Cairo University. Identifications have been checked by Prof. (Mrs.) V. Tackholm, D. Sc., Cairo University, to whom the writer extends his warment thanks. Thanks are also due to Mr. P. A. Moon of the Sudan Geological Survey for revising the section on geomorphology; to Sayed Hassan el-Sheikh of the Sudan Meteorological Service for providing rainfall records; and to Prof. H. Sandon for reading the manuscript.

CLIMATE

Table 1 gives the monthly rainfall records for Omdurman during the period 1942-1954. It will be noticed that there are six rainless months (November-April) and two months (May and October) with scanty

rainfall. The main bulk of the annual rainfalls in July-September : summer rainfall (tropical climate).

The monthly and annual rainfall exhibit noticeable inconsistency. The July rainfall ranges from 195 mm. (1942) to the negligible amount



Map of the desert West of Omdurman.
1. Khor. 2. Jebel. 3. Qoz.

of 1.2 mm. (1949) and the August rainfall from 168 mm. (1952) to 12 mm. (1949). The annual rainfall varies from 260 mm. (1942) to 25 mm. (1949). Great variability is an obvious feature of rainfall in arid climates (Kassas, 1955).

The variability of rainfall is not only temporal, monthly and yearly, but also spatial. The rainfall at Omdurman shows noticeable deviation from that of Khartoum on the other bank of the Nile. In July 1942, Omdurman received 194.7 mm. rain while Khartoum received 110.9 mm. The annual rainfall in 1954 was 239.9 in Omdurman and 165.0 mm. in Khartoum. Worthy of mention in this respect is the rainfall during one day, July 28th 1955 : the Khartoum record is 100 mm., and the Omdurman record is 63 mm. Such local differences express the cloudburst nature of rainfall.

The average Khartoum-rainfall for the period 1942-1954 is 141 mm. which is lower than the normal, 163 mm. (average 1900-1940), given by Ireland (1948). This difference is due to the intervention of three years 1947-1949 with low rainfall (68, 77, 47 mm.). Jebel Aulia, 40 km. (*c.* 25 miles) south of Khartoum, receives an average rainfall of 210 mm., that is, 60 mm. higher than Khartoum. Ed-Dueim, 180 km. (*c.* 110 miles) south of Khartoum, receives an average rainfall of 328 mm., that is, double that of Khartoum. It is true that rainfall increases southward of Khartoum and decreases northward.

Table 2 shows particulars of the Khartoum climate together with synthetic values for aridity indices. The monthly index of aridity P/T + 10 (De Martonne's formula), shows that July and August are the only two months with index of aridity higher than 1. As quoted by Emberger (1952), Andrews and Maze consider 1 to be the limit of « dry month » ; Scaetta regards a dry month as one with an aridity index less than 1.6. According to the latter view, August is the only month which is not dry.

The potential evapotranspiration (PE), calculated after Thornthwaite (1948), is in every month higher than the rainfall, that is, there is a consistent water deficit. The annual index of moisture (I m), Thornthwaite 1948, is -45 which means an *arid* climate ; the annual PE is 188 which means a *megathermal* type of climate.

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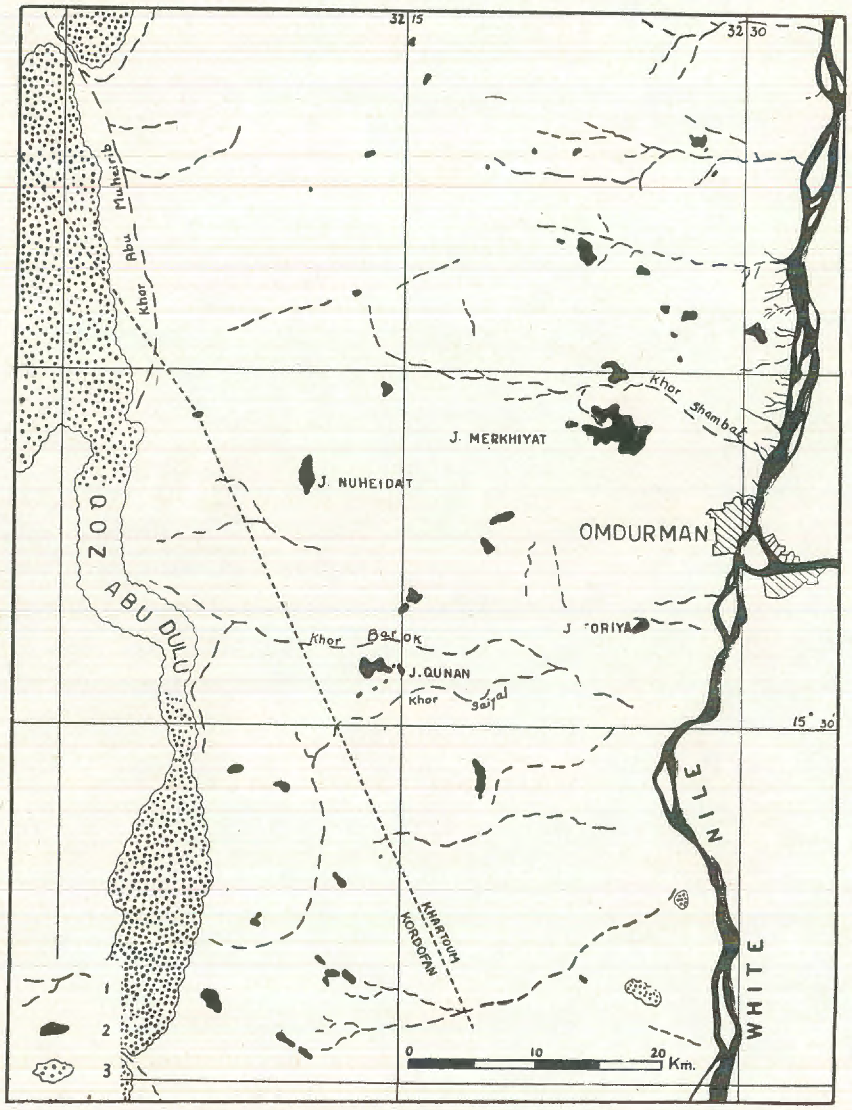

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According to the UNESCO classification of arid climates (Meigs, 1953), the Khartoum climate is of the type Ab 34 : arid climate with summer rainfall and high temperature.

GEOMORPHOLOGY

To the west of Omdurman extends a vast desert plain bearing series of hills and buttes (*jebels*) and dissected by lines of drainage (*khors*). The jebels are, with one exception (J. Toriya), of Nubian Sandstones, J. Toriya is a post-Nubian intrusive body of basalt. Near Omdurman also there is an outcrop of basalt.

The Nubian Sandstone country « has been under subaerial erosion for a long period of time, probably since the Cretaceous. There are few traces of post-Cretaceous events», Andrews (1948). In other words, the Omdurman desert has been under erosion for much longer time than the Eocene limestone desert of Cairo (Kassas, 1953, *b*); Omdurman desert represents a much more advanced stage in the cycle of arid erosion as compared with the Cairo desert. The latter is a limestone plateau dissected by deep wadis; the Omdurman desert is a plain with scattered buttes which are relicts of a once extensive sandstone plateau.

The jebels are composed of beds of feldspathic sandstone, conglomerate and variegated red, lavender and cream mudstones. Secondary processes have resulted in the formation of silcrete and ferricrete layers within the sandstones and conglomerates and also of concretionary ironstone beds. A more recent process has produced a widespread surface crust of ferricrete sandstone.

The flat-topped mesas and buttes are usually topped by resistant beds of ferricrete sandstone. On the exposed sides, slopes or cliffs, lichen growth (crustose) is usually limited to the feldspathic sandstone covering its, otherwise pale, surface with dark colouration.

The deposits forming the present surface of the plain are, to the west, scree, sands and gravels derived from the Nubian series, while to the east occur a series of sands, silts and gravels which have filled the Pleistocene valley of the Nile. Flanking the river these Quaternary deposits are overlain by alluvium distributed by present day floods.

Calcareous horizons, kankar and kankar rubble beds, occur in the Quaternary series. To the south of Omdurman occurs a thick deposit of pisolitic ironstone, which is now generally considered to have been formed from rolled debris of the ironstones of the Nubian series (Andrews, 1948).

The surface deposits show a mosaic pattern which is dependent on quite small differences in level, and on the source of residual material. Slightly higher ground and lower slopes of the hills are strewn with dark ironstone fragments and the typical rounded quartz and jasper pebbles of the Nubian conglomerates. The stream courses are filled by pale outwash sands. Blown sand is banked against the sides of the hills in a few places.

The gravels are extensively quarried for use as concrete aggregate. The surface of the Nubian series beneath the superficial deposits of the plain is often decayed to a clayey or silty layer varying in colour according to the colour of the present rock. These clays are used for brick making and rough pottery.

VEGETATION

General Remarks

The Omdurman district lies within the vegetational belt named Acacia Desert Scrub, Andrews (1948). The boundaries of this formation are, according to Smith (1949), the 50 mm. isohyet to the north, and to the south the 400 mm. isohyet on clays and the 250 mm. isohyet on sands.

The plant cover shows remarkable differences between its seasonal aspects and also fluctuations from one year to another. Table 3 gives records of plants observed within a known plot on four dates. The first record, 17-8-1954, represents the plant cover in its best : the rainy season in a year of good rainfall (240 mm.). The number of species is 78 including about 50 ephemerals and about 20 drought-deciduous perennials. In the second record, 8-2-1955, the number of species is reduced to 33; by this time 46 ephemerals have completed their growth cycle and dried, the remaining plants include a number of ephemerals with a longer season or growth, e. g., *Geigeria alata, Achyranthes*

aspera, Morettia philaeana, Solanum dubium, etc., and a number of perennials. The third record, 23-7-1955, represents the worst state namely, a prolongation of the dry season due to delay in the onset of the rainy season. The record includes 9 species, all of which are hardy shrubs and perennial grasses. The last record, 25-9-1955 represents the rainy season in a less moist year. The number of species is 44, that is, 34 ephemerals recorded in August 1954 failed to appear in September 1955 within the same plot. The difference between the plant growth in the two years is augmented by the great difference in the number of individuals and their cover.

These observations bring out two points : firstly, that the plant cover is subject to substantial changes from one season to the other; secondly, that it is also subject to fluctuation changes from year to year. These are universal features of vegetation but are especially noticeable in desert vegetation, see Kassas (1953, *a*).

The vegetation may best be studied in relation to defined ecosystems which are in fact landform systems. The following pages will give a general picture of the plant cover peculiar to each of the main types of landform without overloading the text with too much botanical detail. Readers will find this report more intelligible if they refer to two previous papers on the Egyptian Desert, Kassas (1952 and 1953, *b*).

The word ephemeral (or ephemeral species) is here used to designate a plant which completes its life cycle in one season. By ephemeral vegetation is meant a plant cover which maintains its growth activities, foliation, flowering, etc. for only a part of the year. This may contain ephemeral species and drought-deciduous species.

The difference between desert communities is only partly due to differences in floristic composition. The salient differences are shown by the dominant species, the relative abundance of associates and the total coverage.

Hills

There are several hills, isolated or in groups, rising above the general level of the plain. As an example we may mention the group of hills to the west of Omdurman, the *Merkhiyat Jebels,* which congregate within an area of about 16 sq. km., and rise to about 480 m. O. D., that is, about 100 m. (*c.* 300 ft.) above the general level of the plain.

These desert hills are either dome-shaped, conical or table-shaped. The latter type provides a flat top of soil-barren rock and cliff-like sides. The beds of sandstone defining the tops are usually ferruginous and harder than the underlying beds. The wide crevices of the top, which are joints in the sandstone, provide room for the growth of a few individuals. Species recorded within this rocky habitat include plants that may better be found in other ecosystems (e. g. *Cadaba farinosa, Maerua crassifolia*) and plants which will rarely be found elsewhere (e. g. *Hibiscus micranthus, Abutilon fruticosum, Gossypium anomalum, Dicoma tomentosa, Forsskalea tenacissima, Heliotropium strigosum* var. *bicolor, Seddera latifolia, Cleome scaposa, Cenchrus ciliaris,* etc.).

The sloping sides of the hills are usually barren except for occasional shrublets of *Cadaba glandulosa.* The slope may be lined with water runnels which are marked by plant growth. Along these runnels the vegetation varies with elevation : nearer to its top, the runnel is lined with large boulders and thin plant cover, whereas the parts nearer to the foot are usually lined with soft materials and thick vegetation. The more gentle the slope, the more gradual will be the change in the texture and depth of the deposits and the greater will be the variety in the plant cover. *Aerva javanica* is the most common species in this habitat type. Nearer to the top it may be associated with *Pavonia triloba* and species recorded for the top surface. Nearer to the foot the vegetation may include *Grewia tenax, Cenchrus pennisetiformis, Enneapogon brachystachyus, Melanocenchrus abyssinica, Anticharis linearis, Cleome paradoxa, Fagonia myriacantha, Tephrosia uniflora, T. nubica, Blepharis edulis* and *Aristida spp.* The lower parts of runnels on the *Qunan Jebels,* which run across very gentle slopes, are lined with soft silts and are covered with rich growth of grass dominated by *Chrysopogon aucheri* var. *quinqueplumis* or *Cymbopogon proximus* (see phot. 1).

Plain

The gently undulating country, which extends to the west of Omdurman, is basically a desert plain pierced by low hills, dissected by a

number of drainage systems (Khors) and mosaiced by patches of the types : gravel desert, erosion pavement and sanddrifts. The type «plain» designates those areas covered with deep alluvial deposits usually brought by sheet floods. It usually lies at a slightly lower level than the surfaces of patches of gravel or pavement, and hence it receives their run-off water.

Where the alluvial deposits are medium textured (loamy), *Acacia nubica* dominates. This shrub, by virtue of its growth form (sitting on the ground), provides a good soil protection. The plant community, an open scrub, is multilayered. The shrub layer includes, apart from *Acacia nubica* whose cover ranges from 10-25 %, occasional shrubs of *Acacia tortilis, Capparis decidua, Ziziphus spina-christi, Maerua crassifolia* and rarely *Balanites aegyptiaca* and *Acacia ehrenbergiana.* A second layer may include : *Cymbopogon proximus, Panicum turgidum, Aerva javanica, Crotalaria thebaica,* etc. A third (ground) layer may include such prostrate species as *Corchorus depressus, Tribulus terrestris, Convolvulus deserti,* etc. During the rainy season a good number of ephemerals appear.

Nearer to the river, where the plain deposits are softer (clayey), *Acacia ehrenbergiana* dominates. Within this community *Cassia senna* is usually abundant. There are a few stretches of this community type to the north of Omdurman, but extensive tracts of it are found on the eastern side of the river (border of the Gezira clay-plain). To the south of Omdurman the plain fringing the river has a few patches of vegetation dominated by *Salvadora persica.* In both these communities *Capparis decidua* is very common.

Gravel Desert

Gravel desert refers to stretches of land where the transported material (mixture of gravels and silts) has been subjected tow ashing and/or deflation which remove the softer material leaving at the surface a cumulus of lag material : gravels or smoothed rock fragments. At a mature stage the gravel layer is so compact (desert armour) that it protects the underlying deposits against further transpiration, and is usually sterile.

At an immature stage (incomplete gravel-cover) the gravel formation provides habitat for an open scrubland where *Acacia tortilis* is the most common shrub. The undergrowth is scanty except for a few ephemerals appearing after rain. At a stage earlier than this, the surface deposits being mixed material, the *Acacia tortilis* scrubland includes a few bushes of *Ziziphus spina-christi, Maerua crassifolia* and *Acacia nubica;* and a number of perennials such as *Panicum turgidum, Tephrosia nubica, Barleria candida,* etc. During the rainy season the plant cover is enriched by the growth of ephemeral grasses (*Aristida spp.*), see phot. 2.

The surface of the mature gravel desert is usually undulated; the furrows guide and contain the run-off water and produce a system of rillets draining into an affluent of a khor or a local basin on the plain. Along the line of a furrow, the floor cover varies in texture and depth. The plant cover varies in coincidence. At the upstream end the floor is the continuation of the desert armour but is occasionally flushed with run-off water. The plant cover is almost exclusively ephemeral : *Aristida spp., Cleome scaposa, Enneapogon brachystachyus, Heliotropium sp.* This may be followed by a section of the furrow where the floor cover is an admixture of gravel and sand; here the plant cover may include such perennials as *Aerva javanica, Cymbopogon proximus, Seddera latifolia.* Where the floor cover is sandy the plant cover includes : *Panicum turgidum, Cassia senna, C. italica, Grewia tenax, Acacia tortilis, Indigofera suaveolens, Tephrosia purpurea, Svensonia laeta,* etc. At this stage the furrow has become a part of a khor affluent.

These furrows of the gravel formation provide the habitat for two small desert bulbs : *Pancratium sp.* and *Dipcadi sp.* It is interesting to note that a similar observation about *Pancratium sickenbergeri* has been made when describing the type « gravel desert» in the Egyptian Desert, Kassas (1952).

Sand Drift

Sheets of sand are deposited in patches of different shapes and areas apparently circumscribed by certain physiographic features, e. g., leeward sides of hillcocks and elevated ground, see phot. 3. The sand may be deposited on top of a sterile gravel desert, alluvial plain, rocky

outcrop, etc. The plant cover shows remarkable differences in coincidence with differences in depth of sand. A thin layer of sand is covered, during the rainy season, by ephemerals such as *Aristida spp.* and *Boerhavia spp.* A deeper layer of sand is usually covered with perennial grass dominated by *Panicum turgidum,* a tussock forming grass which is a good sand binder; but unfortunately it is a favourite fodder plant and hence subject to continuous destruction. Associate plants include *Cassia senna, C. italica, Aerva javanica, Colocynthis vulgaris, Fagonia myriacantha, Corchorus depressus, Tephrosia vicioides,* together with many ephemerals.

On deeper sands *Acacia tortilis* becomes a prominent feature of the plant cover being the most common shrub (5-10 % cover) while *Panicum turgidum* is still dominant in the undergrowth layer (30-50 % cover). Associate species are those listed in table 3.

Khors

A khor is comparable to a desert wadi, being a dried water runnel which may be transformed into an ephemeral stream, see phot. 4. In the Omdurman desert khors are shallow lines of surface drainage cutting across the plain deposits. The main channel of a khor system is usually characterized, apart from being wide, by a central water-way covered with coarse sand and devoid of perennial plant cover, and terraces built of silt where the plant cover is well developed. The central water-way is less conspicuous in the main tributaries and is usually absent in finer rillets.

The vegetation on the khor terraces is often an open forest which is unfortunately subject to destructive lumbering. The tree layer (5-15 % cover) includes : *Acacia raddiana, A. seyal, Balanites aegyptiaca, Boscia senegalensis* and *Commiphora africana.* The last two trees are commonly found to the west of the Kordofan border. The shrub layer (10-25 % cover) includes : *Acacia tortilis, A. mellifera, A. nubica, A. ehrenbergiana, Ziziphus spina-christi, Calotropis procera, Maerua crassifolia, Leptadenia pyrotechnica, Grewia tenax* and *Capparis decidua.* The last may grow into trees of considerable size. *Loranthus acaciae* parasitises *Acacia spp.* and *Ziziphus.* Several climbers include : *Combretum aculeatum, Corallocarpus gijef, Cadaba farinosa, Leptadenia heterophylla, Cocculus hirsutus, Pergularia daemia, Rhynchosia memnonia, etc.* The undergrowth is organised in patches or strips of rich plant cover : *Panicum turgidum, Cymbopogon proximus, Lasiurus hirsutus, Cenchrus pennisetiformis, Aerva javanica, Tephrosia spp., Cassia spp.,* etc. There are also several trailers : *Cucumis ficifolius, C. prophetarum, Colocynthis vulgaris, Merremia pentaphylla, Ipomoea spp.,* etc. During the rainy season numerous ephemerals appear, see phot. 5.

The affluents of the khor may contain a rich growth of *Panicum turgidum* (on sand) or *Cymbopogon proximus* (on silt).

Qoz

Qoz Abu Dulu is an extensive body of sand dune formed during the Quaternary period, and now no longer mobile. The plant cover is essentially a deciduous grassland, yellow in the dry season. In certain lows (saucer-like depressions) there may be stands of *Leptadenia pyrotechnica* community or *Commiphora quadricincta* community, see photos 6 and 7.

The deciduous grassland which is the widespread type of community include a few distantly scattered shrubs of *Leptadenia pyrotechnica, Commiphora quadricincta, C. africana, Acacia tortilis, Cordia rothii* and *Boscia senegalensis.* 50-75 % of the qoz surface is covered by a mixture of grasses : *Panicum turgidum, Aristida stipoides, A. mutabilis, Cenchrus barbatus, C. prieurii, Eragrostis tremula, E. cilianensis, Schoenfeldia gracilis, Enneapogon persicus,* etc. together with *Cyperus conglomeratus. Cymbopogon proximus* is abundantly found along lines of surface drainage and water collecting notches. Associate herbs include species found elsewhere such as : *Fagonia myriacantha, Solanum dubium, Farsetia ramosissima, Geigeria alata, Morettia philaeana, Crotalaria thebaica, Aerva javanica, Tephrosia spp., Cucumis spp., Tribulus terrestris,* etc.; and several species that are rarely found outside the qoz-land : *Chrozophora brocchiana, Heliotropium zeylanicum, Melhania denhamii, Euphorbia scordifolia, Polygala irregularis* and *Sesamum sp.*

Table 1. Monthly and yearly rainfall records at Omdurman and mean rainfall at Khartoum (aerodrome) and Jebel Aulia.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
1942	0	tr.	0	tr.	4.8	1.8	194.7	43.8	4.6	10.9	0	0	260.6
1943........	0	0	0	tr.	4.4	0.9	54.9	47.8	9.2	16.7	0	0	133.9
1944........	0	0	tr.	tr.	0	7.3	136.6	33.5	13.1	tr.	0	0	190.5
1945........	0	0	0	tr.	57.7	tr.	7.4	82.3	27.9	tr.	0	0	175.3
1946........	0	0	0	0	9.8	0.9	45.4	40.3	47.6	0.8	tr.	0	144.8
1947........	0	0	0	0	2.2	6.7	35.7	24.7	16.8	tr.	tr.	0	86.1
1948........	0	tr.	0	tr.	23.5	tr.	11.4	48.3	4.7	6.8	0	0	94.7
1949........	0	0	tr.	0	4.4	tr.	1.2	12.2	tr.	8.0	0	0	25.8
1950........	0	0	0	tr.	11.8	0	111.1	76.8	1.0	0	0	0	200.7
1951........	0	0	0	0	tr.	0	29.0	31.4	4.6	5.5	0	0	70.5
1952........	0	0	0	tr.	0	tr.	4.1	168.1	43.7	0.4	0	0	216.3
1953........	0	0	0	tr.	tr.	0.5	27.5	125.8	53.0	0.5	0	0	207.3
1954........	0	tr.	0	tr.	12.0	0	70.5	89.5	62.1	5.6	0	0	239.9
Omdurman 1942-1954...	0	0	0	0	10.0	1.4	56.1	63.4	22.2	4.2	0	0	157.3
Khartoum 1942-1954...	0	0	0	0	5.5	3.0	49.6	49.6	28.6	4.9	0	0	141.0
J. Aulia 1942-1954	0	0	0	0.2	8.1	6.3	65.3	78.7	34.5	8.3	0	0	201.0

Table 2. Climatic particulars of Khartoum (town), 1900-1940. Rainfall in mm.; mean daily temperature (M. Temp.), mean daily maximum temperature (Mx. Temp.), mean daily minimum temperature (Mn. Temp.) °C; mean relative humidity at 0800 hours (R. H. 0800), mean relative humidity at 1400 hours (R. H. 1400) %; mean daily Piche evaporation in mm.; after Ireland 1948. For synthetic values P/T + 10, PE, Im and UNESCO, see text.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
Rainfall	0	0	0	1	4	9	52	75	18	4	0	0	163
M. Temp.......	23.6	25.0	28.2	31.4	33.6	33.6	31.7	30.6	32.2	32.1	28.4	25.0	29.6
Mx. Temp	32.1	33.8	37.7	40.9	41.9	41.1	38.5	36.7	39.3	40.2	36.5	33.3	37.7
Mn. Temp	15.2	16.2	18.7	22.0	25.2	26.1	24.9	24.5	25.1	24.0	20.2	16.6	21.6
R. H. 0800 ...	36	26	21	18	25	38	57	68	54	37	33	38	38
R. H. 1400....	20	14	11	10	13	19	32	41	30	20	19	22	21
Piche	12.0	14.5	17.0	18.4	17.7	16.3	12.7	9.9	11.4	13.6	13.2	11.7	14.0
P/T + 10.....	0	0	0	0.02	0.09	0.20	1.24	1.84	0.42	0.09	0	0	
PE (Th. 48) ...	8.73	10.01	15.45	17.68	19.87	19.33	19.21	17.84	17.77	17.48	14.41	10.87	188.65
Im (Th. 48) ...	.	.	.	.	.	.	.	.	.	.	.	.	-54
UNESCO......	—	—	—	—	—	—	—	—	—	—	—	—	Ab 34

TABLE 3. Plants recorded, on four dates, within an area of about one square Km. (c. 240 acre = feddan) extending on the south side of the Merkheat Hills.

	17.8.1954	8.1.1955	23.7.1955	25.9.1955
SHRUBS				
Acacia tortilis	+	+	+	+
Maerua crassifolia	+	+	+	+
Ziziphus spina-christi	+	+	+	+
PERENNIALS AND EPHEMERALS				
Aerva javanica	+	+	+	+
Cassia senna	+	+	+	+
Corchorus depressus	+	+	+	+
Panicum turgidum	+	+	+	+
Cymbopogon proximus	+	+	+	+
Lasiurus hirsutus	+	+	+	+
Tephrosia vicioides	+	+	.	+
T. uniflora	+	+	.	+
Crotalaria thebaica	+	+	.	+
Indigofera suaveolens	+	+	.	+
Fagonia myriacantha	+	+	.	+
Tribulus terrestris	+	+	.	+
Geigeria alata	+	+	.	.
Achyranthes aspera	+	+	.	.
Aristolochia bracteolata	+	+	.	.
Colocynthis vulgaris	+	+	.	+
Morettia philaeana	+	+	.	+
Solanum dubium	+	+	.	+
Heliotropium strigosum	+	+	.	+
Blepharis edulis	+	+	.	.
Boerhavia repens	+	+	.	+
B. diffusa	+	+	.	+
B. diandra	+	.	.	+
Farsetia ramosissima	+	+	.	.
Indigofera hochstetteri	+	+	.	+
I. arenaria	+	+	.	.
I. sessiliflora	+	+	.	.
I. cordifolia	+	.	.	.
I. viscosa	+	.	.	.
I. stenophylla	+	.	.	.
Convolvulus deserti	+	.	.	+
Trianthema pentandra	+	.	.	+
Euphorbia aegyptiaca	+	.	.	+
E granulata	+	.	.	.
Glossonema nubicum	+	.	.	.
Ipomoea coscinosperma	+	.	.	.
Eclipta alba	+	.	.	.
Amaranthus graecizans	+	.	.	.
Cleome scaposa	+	.	.	+
C. viscosa	+	.	.	.
Corbichonia decumbens	+	.	.	.
Corchorus tridens	+	.	.	.
Gisekia pharnacioides	+	.	.	+
Glinus lotoides	+	.	.	.
Gynandropsis gynandra	+	.	.	.
Mollugo cerviana	+	.	.	+
Limeum kotschyi	+	.	.	+
Polygala erioptera	+	.	.	.
Pupalia lappacea	+	.	.	.
Pavonia triloba	+	.	.	.
Phyllanthus maderaspatensis	+	.	.	.
Heliotropium undulatum	+	.	.	.
Anticharis linearis	+	.	.	.
Peristrophe bicalyculata	+	.	.	.
Svensonia laeta	+	.	.	+
Cassia tora	+	.	.	.
Cyperus rotundus	+	.	.	.
EPHEMERAL GRASS GROWTH				
Aristida adscensionis	+	.	.	+
A. funiculata	+	.	.	+
A. hirtigluma	+	.	.	.
A. mutabilis	+	.	.	.
A. steudeliana	+	.	.	+
Brachiaria regularis	+	.	.	.
Cenchrus barbatus	+	.	.	+
C. ciliaris	+	+	.	+
C. prieurii	+	.	.	+
Dactyloctenium aegyptium	+	.	.	+
Enneapogon brachystachyus	+	.	.	+
Eragrostis cilianensis	+	+	.	+
E. pilosa	+	.	.	+
Panicum hygrocharis	+	.	.	.
P. glabrescens	+	.	.	.
Schoenfeldia gracilis	+	+	.	+
Tragus racemosus	+	.	.	+
T. berteronianus	+	.	.	+

GENERAL COMMENTS

The foregoing pages will infer that a close relationship exists between the plant cover and the landform. In other words, the physiographic features control the plant cover apparently through its control over the water resources. Datum land, which receives an amount of water equal to the recorded rainfall, does not exist. The differences in surface level, inperceptible as they may be, will cause water to run off from one area and collect in another. The amount of water received depends on the catchment area of the receiving basin : all controlled by topography. The amount of water retained will depend on the texture and depth of the surface deposits (soil). That the soil texture has a controlling effect on the water relationships is best expressed by Smith (1949), «...the tree species which requires $3x$ inches of rain on clay soils requires $2x$ inches of rain on sands». This has also been suggested earlier when we quoted his definition of the southern boundaries of the Acacia Desert Scrub as : 400 mm. isohyet on clays and 250 mm. isohyet on sands.

The sheets of sand drift accumulating on top of sterile gravel desert provide material for studying the relation between soil depth and plant cover. A shallow layer will become completely dry shortly after the rainy season has come to an end. Only ephemerals can survive. A deeper bed of sand will provide room for water storage in the subsoil and will allow for the growth of perennials. On these sand sheets one can follow the gradation from an ephemeral plant cover, to a drought-deciduous grassland, to an evergreen grassland and finally an open scrubland of *Acacia*.

Human interference ranks second only to the water factor in affecting the plant growth. A few kilometres to the west of Omdurman the Forestry Department established a 5 acre enclosure a few years ago. This has been extended this year (1955). The difference between the plant cover inside the enclosure (20-80 % grass cover) and that outside (less than 5 % cover) is outstanding even in the newly established enclosure, see Phot. 8. The enclosure not only protected the

plant cover but also allowed for the accumulation of soft deposits (wind and water-borne) and the building up of the ground level inside the enclosure. This is especially marked along the perimeter.

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PHOTO 1. Jebel Qunan, Feb. 1954. The gentle slopes are covered with rock fragments, the plant cover (dried grass) is confined to the water runnels. In the background is seen an extensive plain with a dome-shaped butte and scattered bushes.

PHOTO 2. An area where the surface deposits are mixed material, observe a certain amount of pebbles in the left-hand foreground. *Acacia tortilis* is dominant, Feb. 1954.

PHOTO 3. In the foreground is a sterile area of an erosion pavement showing the surface accumulation of scree. The midground shows the plant growth limited to line-depressions. In the background is seen a butte with sand accumulation on the leeward (left hand) side, Feb. 1954.

PHOTO 4. Khor Abu Muheirib, 8 a.m., 12 Sept. 1954. Two hours earlier this was a stream roaring with a strong torrent : an ephemeral activity which eventually subsided. During the night a cloudburst caused a heavy rainfall. Observe that the central part of the Khor, the water way, is devoid of vegetation; rich plant growth on the terraces on both sides.

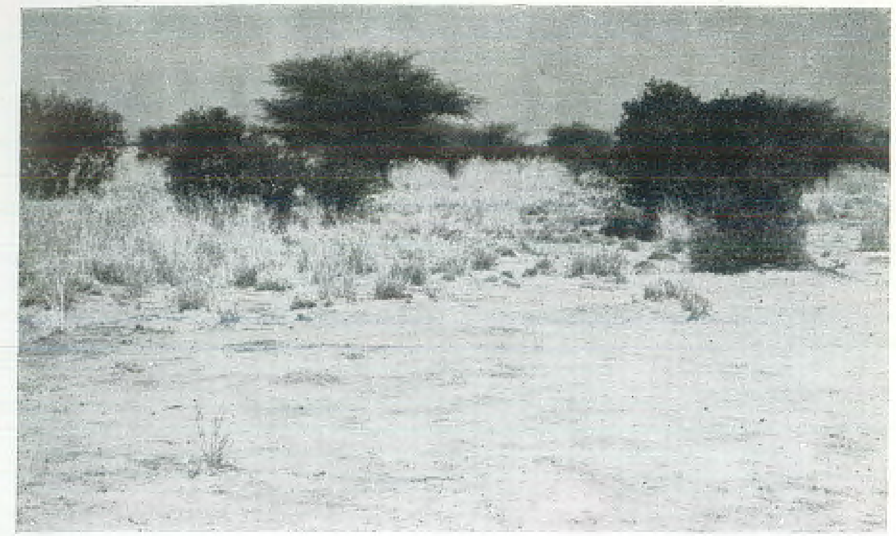

Photo 5. Khor Barok, Feb. 1954. The vegetation is multilayered. The grass (*Panicum turgidum*) undergrowth is well developed. The foreground is a part of the waterway with little plant cover.

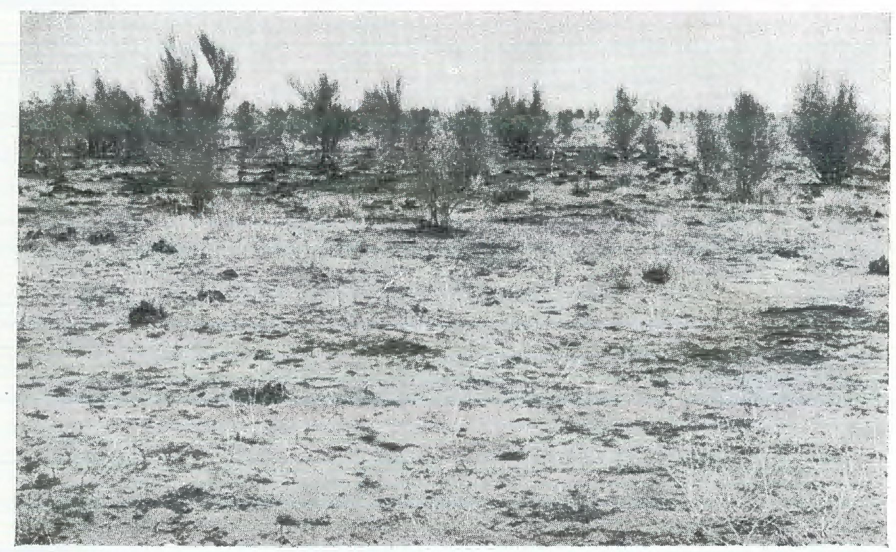

Photo 6. Qoz Abu Dulu, Sept. 1954. The grass vegetation is burnt : clearing for planting patches of millet. A stand of *Leptadenia pyrotechnica* is seen in the midground.

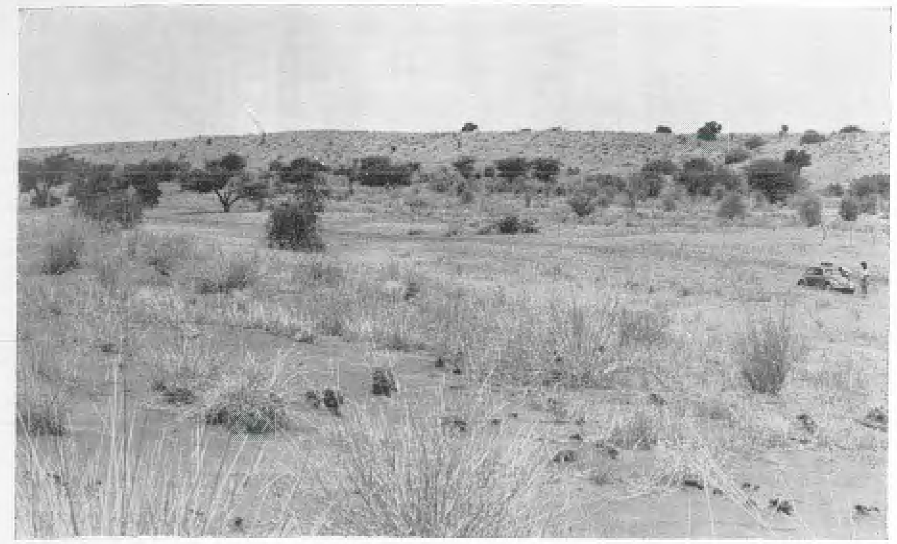

Photo 7. Qoz Abu Dulu, Sept. 1954. A general view of the qoz and its vegetation. In the foreground and the far background are seen the higher parts of the qoz with grass plant cover, *Panicum turgidum* may be recognized. In the midground is a «low» with rich population of *Commiphora quadricincta*.

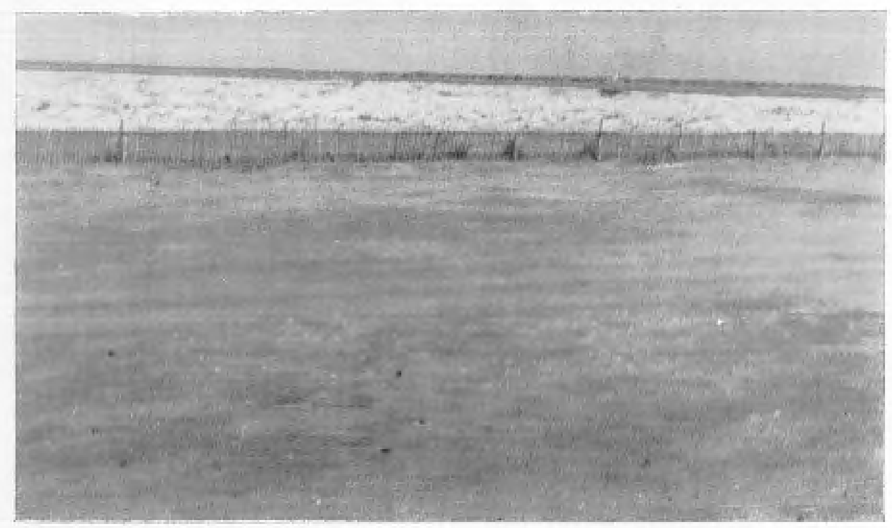

Photo 8. Enclosure west of Omdurman, July 1953. The foreground is barren land (outside). Within the enclosure is a rich growth of grass.

POST GLACIAL CLIMATIC CHANGES
IN NORTH WESTERN EUROPE

BY

ABD EL-AZIZ TORAYAH SHARAF

For many years, the study of the post glacial climatic changes have been stimulating the thought and work of writers more than almost any other branch of climatology. Such changes may be put under two main categories; first of all, the major changes which occurred just before and throughout historic times, most of which persisted over periods of the order of centuries. Secondly, the « ups and downs» which have been characteristic of the climatic conditions during the last few centuries. The changes of this category may cover only short periods (e. g. scores of years), and are usually referred to as « fluctuations».

Notwithstanding the increasingly obvious importance of studying all the above mentioned climatic alterations because of their profound influence and serious consequences in almost all aspects of both past and present history of the earth, it will not be possible to give here more than a short outline of the better established evidence, theories and conclusions produced by writers in various branches of science.

Geology, botany, zoology, anthropology, climatology, meteorology, astronomy and other kindred sciences are daily supplying an almost overwhelming mass of fresh evidence, which have left no room for doubt as regards the reality of the changes concerned. Nevertheless, the prospects of reaching an agreement on their possible causes are still out of sight.

The most important post glacial climatic changes in northern and western Europe, for which there has been quite satisfactory evidence may be summarized as follows :

a. Just after the close of the Ice Ages, came a period of extreme climatic conditions, with cold winters and, towards its end, hot summers.

b. Then came a period of mild winters during which rainfall was perhaps greater than at present. Beginning about 6000 B.-C. and ending just before 3000 B.-C., this period was contemporaneous with the glory of the Stone Age and it is often known as the « period of optimum climate».

c. The « Subboreal» period followed the period of optimum climate, and was on the whole a succession of very dry and very wet periods, the last of which was a very dry warm spell lasting for one century from 800 B.-C. to 700 B.-C.

d. A period of very cool rainy climate started almost abruptly about 500 B.-C. and lasted about 1000 years. This is the « Subatlantic» period, the beginning of which constitutes perhaps the most definite and outstanding climatic change in post glacial times.

e. The more recent climatic fluctuations which have been noted during about the last thousand years, started with a general tendency towards colder climates, and is ending at present by a slow change towards warmer conditions.

This climatic chronology has found considerable evidence in many parts of the world especially the countries of northern and western Europe and the northern Atlantic; but as the sum of evidence bearing on the subject is too immense to be covered in this general review, we will mention only the most important indications of climatic changes.

In the first place there are biological and botanical indications related to the prevalence or disappearance of certain marine and terrestrial species of plants and animals during particular periods. For instance, the prevalance of warmth-demanding species of trees such as the « Tilia» in north-west Europe during the period of optimum climate is very good evidence for the mildness of that period. Such warmth is also reflected in the height of the forest-belt on the mountains; mixed oak forests became dominant during the period of optimum climate at levels where pine had been dominant before (1). The same could be said about the moisture-loving plants such as the bog formations which thrive with increasing rainfall, and diminish or disappear altogether in dry periods. The existence of peat-bogs related to certain parts of the « subboreal» period has led to the abandonment of an earlier belief that very dry conditions persisted without any interruptions during the whole period, and proved that it was in fact alternations of wet and dry periods (2). Further biological evidence is the variation in the width of spacing between the annual rings of growth in certain trees (the sequoias of California), this being greater under milder and more rainy conditions. Migrations of certain kinds of sea and terrestial animals to the south in cold, and to the north in warm periods are also well known indications of climatic change.

More evidence bearing on the subject may be also sought in the old records of floods and droughts, early writings and legends, ancient people's settlements and migrations, variations in the surfaces of lakes and rivers, the work of glaciers and running water in shaping the surface of land...etc. But it is worth mentioning that most of the material that could be collected from the above mentioned sources or others, must be treated with great care and circumspection. It should not be taken for granted that any changes in the levels of lakes or rivers were due to climatic alterations; in many cases they were planned by man for economic or other purposes. Again the migrations of peoples or their invasions could have been determined by other factors which had nothing to do with climate, such as the outbreak of an epidemic disease, or the prospects of a better life somewhere else. To similar causes might also be attributed the disappearance of some kinds of animals from certain regions.

As regards the more recent climatic fluctuations, we are fortunate to find a few fairly reliable, though scattered instrumental climatic records covering a good number of years. In 1940 A. Labrijin published the longest series of records (starting from 1706) collected from Holland (3). The next longest series starts from 1753; it was collected by G. Manley from Lancashire and published by him in 1946 (4). The above mentioned records, together with other records collected from different countries in northern and western Europe, have been analyzed, plotted and compared in a considerable number of publications (5).

Almost all comparisons show two interesting phenomena : the first is that there is a general parallelism among the trends of the temperature curves based on data from various sources; the second is that there is a general tendency towards warmer conditions throughout the

last two centuries. This warmth however, is likely to be interrupted by occasional occurrence of extremely cold periods. These phenomena are apparent in the curves of Figs. 1 and 2.

In attempting to define the causes of the post glacial climatic changes

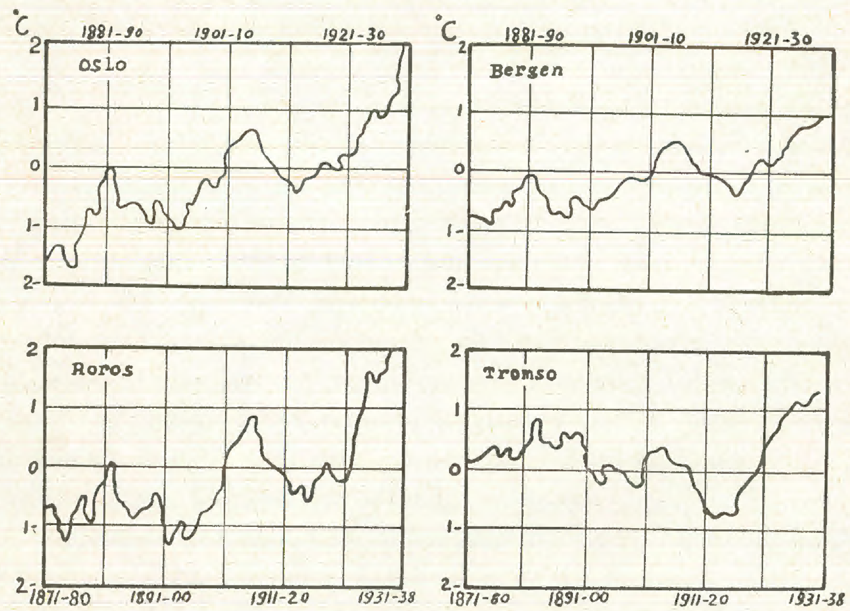

Fig. 1. Temperatures at stations in Norway plotted in ten years overlapping means (H. W. Ahlmann 1949)

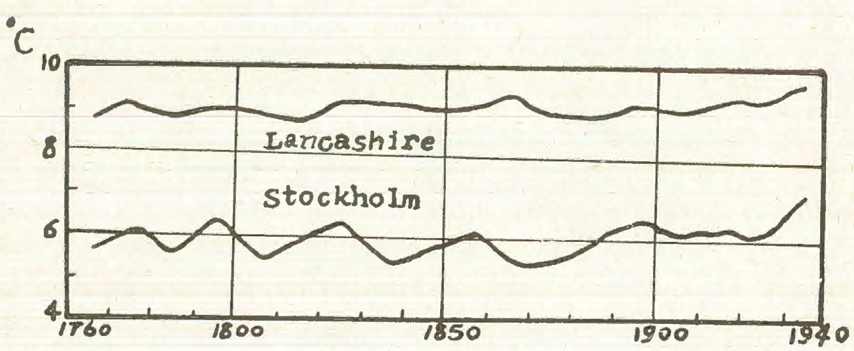

Fig. 2. A comparison between temperatures (annual means) at Stockholm and Lancashire plotted in ten years overlapping means (A. H. Ahlmann 1949)

as a whole and the present fluctuations in particular, an increasingly large variety of theories and explanations are being brought forward by writers in different sciences, notably in meteorology and astronomy. The most popular theory at present, is perhaps the one based on possible variations in the vigour of the atmospheric circulation.

The theory that variations in the atmospheric circulation are responsible for some climatic changes was first suggested by A. Defant in his two well-known publications on « the atmospheric circulation in temperate latitudes» and « the atmospheric circulation over the North Atlantic», in 1921 and 1924 respectively (6, 7). The theory has gained considerable support in the works of other investigators, though only with regard to the causes of the present improvement of climate as indicated by the general rise of temperature. Concerning the earlier changes, however, there is still much doubt as to whether the theory can provide a satisfactory answer. Part of the main evidence for the validity of this theory has been given by B. E. Eriksson in his analysis of barometric pressures, winds and drift ice in the northernmost Atlantic (8). Eriksson states that there has been a general intensification of the atmospheric gradient in these regions which, consequently, receive more supplies of warm air from southern latitudes. Similar results have been reached by many other writers, but we will not be able to go here into any detailed arguments.

However, it may be relevant to draw attention to the fact that, in trying to define the factors of the climatic change, one should not bank on one factor as the only cause of changes and variations from time to time; different factors might work at different periods, and more than one factor might be effective at the same time. Following the retreat of the Ice Age glaciations, for instance, the extreme continental conditions which prevailed might be best attributed, as E. P. Brooks suggests, to a combination of two causes, firstly, the increase in the inclination of the earth's axis, and, secondly, the passing of the earth out of the position in which the northern hemisphere was in the aphelion in winter. Due to these two factors the annual variation of solar radiation was very high in the northern hemisphere, and consequently the range of temperature was very high (2).

As regards the period of the climatic optimum, the explanation given

by Sir George Simpson has been described by Brooks as the most reasonable at present; according to this explanation the warmth of that period was caused by excessive solar radiation; the high temperatures in turn enhanced evaporation and so rainfall was also increased (2).

Moving to the next period, the subboreal, different factors might have caused the striking alternations of wet and dry periods; these factors were associated with the stability of the floating ice cap of the Arctic ocean, which was dependent on the conditions that prevailed there. When conditions were quiet, the ice cap remained compact and little ice found its way out, but when the Arctic was disturbed, very likely by tidal forces, the ice cap broke up and large amounts of ice drifted out into the Atlantic, increasing the chances of storms and rainfall. The frequency of storms and the increase of rainfall were experienced all over the north temperate regions as a result of the profound influence of the drifted ice on the tracks of depressions.

In respect to the latest changes, those of the last two centuries, the variations in the strength of atmospheric circulation seems to provide, for the time being, the most acceptable explanation. This explanation has been generally supported by some writers such as G. Manley (9) and Ahlmann (5). Other writers, however, prefer to consider these latest changes as merely random fluctuations with no definite causes which can be isolated; they just happen as fluctuations happen in any series of random events. Brooks, for instance, states that, as the atmosphere is always oscillating in a complex way, quite minor occurrences like the passage of depressions may initiate apparent changes of climate.

Thus, in spite of the immense work that has already been accomplished, much work still remains to be done before one can make any definite statement about the causes of the post-glacial climatic changes. Other possible causes might be associated with the cycle of sun-spots, or with the continuous changes in the surface of the earth which are planned by man, such as the distribution of forests and the use of irrigation in many areas. Intense volcanic activity during certain periods may also have had an effect on past climates; this may have caused some reduction in insolation, which in turn may have meant a fall in mean temperature, and hence, encouraged the growth of glaciers in normally

marginal climates. It should be mentioned, too, that our present knowledge of the extent of the climatic changes is hardly comprehensive enough to allow us to characterize it as worldwide, especially when the present fluctuations are concerned. It may be quite reasonable, as almost all evidence given is from the British Isles and N.-W. Europe, not to dismiss the possibility that the climatic fluctuations occurred only in these regions, due to their marginal position between a marine and a continental climate, and relatively small changes in the activity of atmospheric circulation might have remarkable consequences.

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2. Brooks, E. P., « Causes of Climatic Fluctuations » Q. J. R. Met. S., vol. 75, 1949, No. 324, 172-173.
3. Labrijin, A., « Het Klimaat van Nederland gedurende de laatste twee en enn halve eenw » (with an English summary), Kominklijk Nederlandsche Met. Inst., No. 102, Meded, Verhadelingen, Grabenhage, 49 (1945) 1-114.
4. Manley, G., « Temperature Trend in Lancashire », Q. J. R. Met. S., vol. 72, 1946, pp. 1-31.
5. Most of the recent works that have been done in the subject up to the beginning of 1949 has been well summarised in two papers :
   a. *Son Ahlmann,* H. W., « The Present Climatic Fluctuations, Geog. J., vol. 112, Nos. 4-6, 1949, pp. 165-195.
   b. A very useful contribution made by writers in botany, climatology, meteorology and astronomy in a joint meeting of the R. Ast. Soc. and The R. Met. S. on December 15th 1948; Q. J. R. Met. S., vol. 75, No. 324, 1949, pp. 161-195; the contributors include among others: E. P. Brooks, G. Manley, and H. Godwin.
6. Defant, A., « Die Zirkulation der Atmosphäre in den gemässigten Breiten der Erde », Geogr. Ann., vol. 3, 1921, pp. 209-265.
7. —— « Die Schwankungen der atmosphärischen Zirkulation über dem Nordatlantischen Ozean im 25-jährigen Zeitraum 1881-1905 », Geogr. Ann., vol. 6, 1924, 13-41.
8. Eriksson, B. E., « Till Kännedornen om den Nutida Klimatändringen inom Omrädene Kring Nordligaste Atlanten » (with an English Summary), Geogr. Ann., vol. 25, 1943, pp. 170-201.
9. Manley, A., « The Extent of the Fluctuations Shown during the 'Industrial' Period in Relation to Post Glacial Events in N. W. Europe », Q. J. R. Met. S., vol. 75, No. 324, 1949, pp. 165-171.

THE GEOLOGY
OF GEBEL IWEIBID-GEBEL GAFRA AREA, CAIRO-SUEZ DISTRICT

BY

N. M. SHUKRI AND M. K. EL AYOUTY

I. INTRODUCTION [1]

This paper deals with the geology of Gebel Iweibid-Gebel Gafra region, an area of about 300 square km that lies 40 km to the northwest of Suez (Fig. 1 and Photo 1).

Besides the study of the surface geology of the area, this work deals with the sediments anticipated in the subsurface. It includes also a study of its structure in relation to that of the Cairo-Suez and the Gulf of Suez Districts. The oil possibilities of the Cairo-Suez District, and those of the northern part of Egypt in general are discussed and an attempt is made to describe its geological history. The mineralogy of sands and sandy limestones of the Upper Eocene, Oligocene, Marine and non-Marine Miocene in the area is given in another publication (Shukri and El Ayouty, 1956).

The geology of the present area was dealt with for the first time in a somewhat detailed form by Barron in his work on the geology of the district between Cairo and Suez (1907). In this work, Barron gave the general topographic and geologic features of the area on a scale of 1 : 250.000. Barron recorded sediments ranging from Middle Eocene

[1] The writers are indebted to Dr. R. Saïd for reading the manuscript and for fruitful discussions. Thanks are also to Mr. B. Faragalla for help in the field.

(Lower Mokattam) to Recent. The Miocene is shown on his map to occupy the larger part of the area around Gebel Iweibid itself and to contain fossils « mingling between Lower and Middle Miocene» (*op. cit.*, p. 43). The sands and gravels below the Miocene were shown by him to belong to the Oligocene. Barron recognized an unconformity between the Middle and Upper Eocene (Lower and Upper Mokattam) at the western end of Gebel Iweibid (*op. cit.*, p. 84), as well as other unconformities above and below the Oligocene. He described Gebel Iweibid itself as a horst which « owes its origin to a fault which had let the country down on all sides» (*op. cit.*, p. 21); in another occasion, he referred to it as « a big fold in the Eocene in the troughs of which the Miocene was deposited» (*op. cit.*, p. 94). He considered the faults in the area covered by the present work, as well as in the district between Cairo and Suez in general, to be of post-Miocene age, though not necessarily produced at the same time (*op. cit.*, p. 111). On the other hand, he described the emission of the basalts and the silification processes in the district to pre-Miocene times (*op. cit.*, p. 68).

Blanckenhorn described Gebel Iweibid as a horst and considered the faulting in the district as pre-Miocene in age (1901), but in a later publication, however, he agreed with Barron as to the post-Miocene age of the faulting (1921, p. 118).

Barthoux, in his generalized study of the igneous rocks of the Eastern Desert, referred briefly to Gebel Iweibid, where he considered it as a horst block (1922, map 4, p. 112), consisting of Middle Eocene (Lower Mokattam) sediments with Upper Eocene (Upper Mokattam) on top (*op. cit.*, geol. map). He considered the sands and gravels to the north-east of the horst (and the corresponding gravels along the Cairo-Suez District, including the Gebel Ahmar sands) as of Pliocene-Pleistocene age (*op. cit.*, pp. 95-100). He described the basalts of the Cairo-Suez District (his Mediterranean basalts) and attributed them to the Miocene (Schlier), contradicting in this respect Barrons' conclusions as to the pre-Miocene (Oligocene) age of the basalts of the Gebel Ahmar sands and of the silicification in the Cairo-Suez District in general (Barron 1907, pp. 90-94). The Miocene around Gebel Iweibid was considered by Barthoux as Helvetian in age.

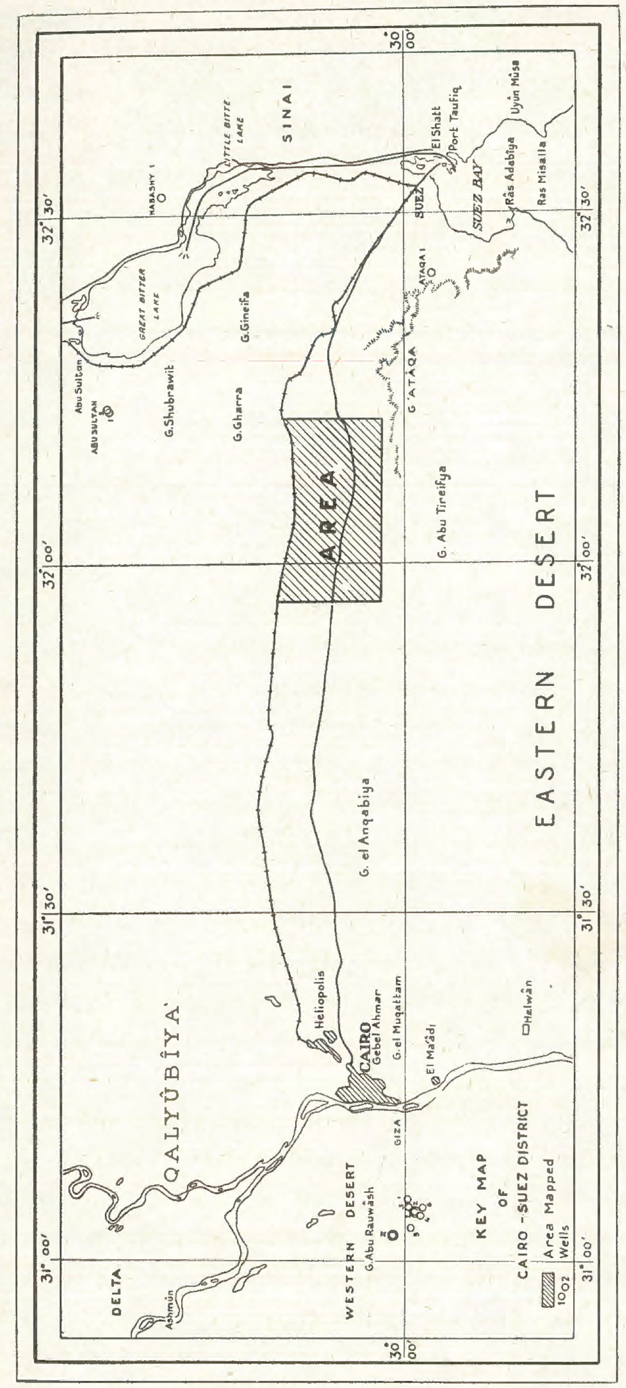

Fig. 1. Key map of Cairo-Suez District showing area mapped. Approximate scale 1 : 1.250.000.

Though Sandford and Arkell did not discuss in detail the geology of the area in question, yet they commented on the « Pliocene» of Barron at Tower 12 (*op. cit.*, pp. 52-54), and considered it as belonging to the Upper Miocene representing a passage from marine to wadi-gravel conditions (Sandford and Arkell 1939, p. 7). They also claimed the presence at the foot of the eastern extremity of Gebel Iweibid of « an oyster bed composed of a mass of perfect specimens of the Miocene Ostrea virleti, growing upon the foot of a faulted cliff of Cretaceous strata tilted almost vertically» (*op. cit.*, pp. 23-24).

Besides the works of Barron, Blanckenhorn and Barthoux mentioned above, other workers, while studying certain localities in the neighbourhood, made some general remarks which apply to the present area.

Sadek, in his study of the geology of the district between Gebel Ataqa and El Galala El Bahariya discussed the tectonics of the district and assigned a pre-Miocene age to the N.W.-S.E. faults and a post-Miocene age to those trending E.-W. He also stressed the minor rôle played by folding in consequence of the bend of the beds into the fault lines, and that the movements were mainly of a vertical nature, possibly due to the relative rise and fall of blocks of the granitic complex underneath (1926, pp. 113-114). It is worth mentioning that Sandford and Arkell adopted Sadek's views with regards to the age of faulting and to its importance relative to folding (Sandford and Arkell 1939, pp. 4-5).

More recently, the area directly to the east of Cairo (Shukri 1953 *a*) and that of Gebel El Anqabiya and Gebel El Nasuri (Shukri and Akmal 1953) in the Cairo-Suez District were mapped. The latter authors stressed the importance of the presence of two stratigraphically different gravel series, one above the Eocene (Oligocene) and the other above the fossiliferous Marine Miocene (non-Marine Miocene). They attributed folding to lateral compressive forces that ended in the early Oligocene and considered the two sets of faults, the N.W.-S.E. (Erythrean) and the E.-W. (Mediterranean) to have been initiated in pre-Miocene times and that rejuvenation of movements along those older fractures of both systems took place in later post-Miocene times (*op. cit.*, pp. 261-262).

The available topographic map of the present area is on a scale of 1 : 100.000 (Plate I). The area was geologically mapped on a scale of 1 : 25.000 (Plate II) using plane table and alidade, with the government triangulation points No. S 210 (515 m) and No. Q 440 (520 m) as base line.

II. GEOGRAPHY

The area mapped includes Gebel Iweibid in the east, and the eastern side of Gebel Gafra in the West. It is bounded to the north by the Cairo-Suez Railway line and extends southward for some 2 km to the south of the Cairo-Suez Road.

Gebel Iweibid is the boldest topographic feature in the Cairo-Suez District (Photo 1). Another topographic high which is of less importance in the area is a feature south-west of Gebel Iweibid (referred to later as the South West Horst) (Photo 2) and a third, still much less conspicuous, is present south of Gebel Iweibid (referred to later as the South Anticline).

The topography of the area is controlled to a great extent by its geology; the topographic highs are also structural highs. Tectonic movements are responsible for the formation of two horsts : the Gebel Iweibid and the South West Horsts, where the exposed resistant Middle Eocene limestones formed the high topographic features of the area. Those two topographic highs are surrounded by downthrown beds which form a low land of less resistant Upper Eocene, Oligocene, Marine Miocene and non-Marine Miocene sediments. The Upper Eocene and the Marine Miocene sandy limestones form escarpements and dip slopes topography whereas the Oligocene and non-Marine Miocene sands and gravels form rounded dark hills covered with lag gravels, left behind after the deflation of the finer sands.

The Gebel El Gafra high exposes a core of Oligocene gravels which is covered on the northern side by the younger Miocene sediments.

The Gebel Iweibid and Gebel Gafra highs are separated from Gebel Shubrawit—Gebel Um-Raqm—Gebel Um Qamar highs farther north by a topographic low which is occupied by the Cairo-Suez Railway line.

Another low is found farther south, separating the Gebel Iweibid-Gebel Gafra highs from the high cliffs of Gebel Ataqa—Gebel Tireifya; the Cairo-Suez motor road extends along parts of this low.

The Iweibid-Gafra drainage is a radial drainage modified by faulting. The main drainage in the northern part of the area runs from the Middle Eocene highs of Gebel Iweibid and the South West Horst, northwards to the railway depression, to join Wadi Abu Awasig which passes northwestward across the railway line. Other smaller tributaries that drain the northern cliffs of Gebel Iweibid or its western extension disappear in the topographic low of the railway, which serves as a collecting area for their waters, and considerable amounts of Middle Eocene pebbles and boulders that abscure the older formations are present in that topographic low. On the other hand, many tributaries flow down the southern and south-eastern side of Gebel Iweibid to join Wadi Abu Sakran and Wadi El Homeira that mainly drain the westward extension of the Gebel Ataqa range. The main tributaries in this part are to a great extent governed by fault lines. At the extreme west the southern tributaries join the Wadi Um Sayal (also flowing down the cliffs of Gebel Ataqa range) to join Wadi El Gafra which cuts through the topographic high of Gebel Gafra owing to the existence of a fault line at that part of the Gebel. None of the wadies in the area cut through Gebel Iweibid or its south-west extension (the S.-W. Horst). These seem to have stood out boldly as drainage sheds in pre-Miocene times.

III. STRATIGRAPHY

A. SURFACE

The sediments in the Gebel Iweibid-Gebel Gafra area range from Middle Eocene to Recent. Pre-Eocene formations (Cretaceous) are, however, exposed at two localities some 28 km to the North-East and South-East of Gebel Iweibid, namely, at Gebel Shubrawit and Gebel Ataqa respectively. A careful examination of the present area showed that the Cretaceous strata described by Sandford and Arkell at the foot of the eastern extremity of Gebel Iweibid (1939, pp. 23-24) are not present.

The stratigraphic succession of the sediments in the present area is as follows :

	Thickness.
RECENT.	
Pliocene	30 meters
—— Unconformity	
Non-Marine Miocene	+20 meters
—— Unconformity	
Marine Miocene	80 meters
—— Unconformity	
—— Basalt	25 meters
Oligocene	
Sands and Gravels	+45 meters
—— Unconformity	
Upper Eocene	63 meters
Middle Eocene	+200 meters

1. EOCENE.

The Eocene sediments form the core of Gebel Iweibid, and the S.-W. Horst. Both Middle and Upper Eocene strata are exposed in the area. The Base of the Middle Eocene is unexposed. To the south-east, however, at Gebel Ataqa the Middle Eocene rests unconformably on the? Lower Senonian-Turonian limestones. Farther south at Gebel El Galala El Bahariya, on the other hand, the Middle Eocene rests on the Lower Eocene. The probable sub-surface section and the relation between the Cretaceous and Eocene sediments in the present area are discussed later.

a) *Middle Eocene* (Lutetien).

The exposed Middle Eocene, not less than 200 m in thickness, is composed of white and chalky limestones with occasional marls near the top; the limestones are mostly hard and crystalline, that weather brown and dark grey, giving the structure a somewhat dark colour from a distance. The limestones at places assume a red or violet colour due to weathering particularly at the upper part of the section on the south western side.

The Middle Eocene of Gebel Iweibid and of the South West Horst is very poor in megascopic fossils. The lower 100 m were found barren of them. Higher in the section, near the top, more fossils are encountered, mainly *Natica longa, Gisortia gigantea* and some other badly

preserved gastropods and pelecypods. Near the top of the series, the marls occasionally encountered contain some *Anisaster* and *Sismondia* spp.

b) *Upper Eocene* (Bartonian).

At the western side of Gebel Iweibid, the Upper Eocene is some 63 m thick and consists of pale brown and yellow sandy limestones and marls with occasional sandstone bands, and seems to lie conformably on the Middle Eocene. Beds of Upper Eocene age outcrop also to the south west of Gebel Iweibid. These are affected by the Gebel Iweibid South fault, F_2, and are downthrown against the Middle Eocene limestones. Apart from these two main outcrops, Upper Eocene beds outcrop in small patches which are down thrown against the Middle Eocene at five localities along the northern side of the Iweibid Horst. A narrow strip of Upper Eocene sediments is also recorded for the first time to the west of the S.-W. Horst. This exposure is believed to be due to a fault along its southern side.

The Upper Eocene sediments are soft when compared with the hard and resistant Middle Eocene limestones and chalky limestones. The colour and lithology of the beds make them easily distinguishable from the underlying Middle Eocene and the overlying Oligocene sands and gravels. The marked change of lithology and fauna between the Middle and Upper Eocene formations seems to reflect a change in the environmental conditions of deposition, the Middle Eocene being deposited in deeper water whereas the Upper seems to have been deposited in a shallow water neritic environment.

The Upper Eocene is rich in fossils, especially at its lower part, with abundant *Carolia placunoides, Ostrea Clot-Beyi* and *Ostrea multicostata,* together with many Echinoids, such as *Sismondia* and *Anisaster,* pelecypods and gastropods. Occasionally the oysters are so abundant as to form entire banks. *Nummulites striatus* was found in a limestone bed at the base of the series.

The following is a description of a composite section of the Upper Eocene in the area, starting from the top :

Meters.		Total.
15	Yellow sandy limestone, poorly fossiliferous, hard with occasional sand bands towards the top	15 meters
3	White to pale yellow, gypsiferous, medium hard, unfossiliferous marls	18 meters

0.5	Sandy limestone, medium hard, with abundant *Ostrea multicostata, Anisaster gibberulus* and casts of pelecypods	18.5 meters
8	Yellow, fine grained, solid and hard marl with few *Carolia placunoides,* casts of Ostrea and Echinoids.............	26.5 meters
5	Pale brown, sandy limestone with abundant *Ostrea multicostata* and *Carolia placunoides*	31.5 meters
3	*Carolia placunoides* bed...............................	34.5 meters
5	Yellow, fine grained marly limestone, poorly fossiliferous with some casts of pelecypods	39.5 meters
5	*Carolia placunoides* bed...............................	44.5 meters
1	White hard limestone................................	45.5 meters
3	Yellow limestone rich in fossils : pieces of oysters, *Turritella* sp. and casts of pelecypods	48.5 meters
0.5	Sandy limestone with oysters (*O. Clot-Beyi* and *O. multicostata*), echinoids and few *Carolia placunoides*...........	49 meters
0.5	Sandstones and calcareous sandstone, yellow, occasionally grey or ferruginous	49.5 meters
5	Yelow sandy marls, occasionally-ferruginous, with *Carolia placunoides, Ostrea Clot-Beyi,* few *O. multicostata, Turritella* sp. and pelecypods..................................	54.5 meters
0.5	*Carolia placunoides* bed...............................	55 meters
4	Interbeds of marls and limestones with *Ostrea Clot-Beyi, Sismondia Blanckenhorni,* few *Carolia placunoides* and other casts of echinoids..................................	59 meters
4	Brown to yellow limestone with *Nummulites striatus*.....	63 meters

At the extreme western side of the area under discussion, Barron showed on his map an outcrop of Upper Eocene sediments. The occurrence of this outcrop is doubtful as proved by a thorough examination of the locality. The writers believe that this mistake in Barron's map may be due to a misprint, since both the map and text were published after Barron's death. The position of this outcrop as shown on Barron's map between the basalt and the gravels, both of which belong to the « Oligocene», justifies this belief.

2. « Oligocene ».

The « Oligocene» of the Gebel Iweibid-Gebel Gafra area consists of sands and gravels with basalt flows on top.

a) *Sands and Gravels.*

The gravels frequently present along the Cairo-Suez District had been the subject of controversy for a long time. It is now known that

these gravels belong to three different ages : « Oligocene », Miocene and Pliocene (Sandford and Arkell 1939, Shukri 1953 *a* and *b* and Shukri and Akmal 1953).

The sands and gravels attributed to the « Oligocene » are always overlying unconformably the upper Eocene sediments and underlying unconformably the basal beds of the Miocene. The « Oligocene » age of those gravels is inferred from their stratigraphical position, their continental nature (in contradistinction with the overlying and underlying marine sediments), and their correlation with the stratigraphically similar horizon of the fluvio-marine series of the Fayoum in the Western Desert, which yielded vertebrate fossils of Oligocene age.

The « Oligocene » sands and gravels can be traced for a long distance to the west of the area, where they form the core of Gebel Gafra. They occur also in many localities in the district between Cairo and Suez.

The sediments, about 45 m thick, are mainly false-bedded sands and sandstones of brown, dark brown and yellow colours. Red colouration is also noticed at many localities and is almost confined to the level just below the lowermost beds of the overlying Marine Miocene. Associated with the sands and sandstones, flint gravels occur on their surface. These are lag gravels that are concentrated by the deflation of the finer sand matrix.

No fossils are seen, except for the common silicified wooden trunks that may reach 25 m in length and 0.75 m in diameter. The fossil wood fragments and trunks are not evenly distributed but are found clustered in some localities whereas they are very few or absent in other localities. When present, they tend to lie down along nearly the same direction. They are particularly abundant to the south-west of Gebel Iweibid.

The presence of fossil wood as well as occasionally hardened sands and gravels into dark coloured quartzites and conglomerates along and near fault planes gives indication of the occurrence of silicification in the area. It seems that silicated waters passed laterally in the porous sands and gravels during their ascent along the fault planes to produce the features just described.

Barron expressed his belief that the sands and gravels of comparable

stratigraphical horizons along the Cairo-Suez District could be derived from the Nubian Sandstone, while the pebbles of chalcedony, flint etc. could have been derived from the silicious beds or from the flinty layers of the Cretaceous limestones (1907, p. 69). In a more recent work, however, the present two authors (1953) found that the heavy minerals of the sands in question show affinity not only to the Nubian Sandstone assemblage, but also to a crystalline provenance rich in metamorphic minerals, especially sillimanite, the source of which being situated to the south.

The « Oligocene » sands show a characteristic mineral assemblage which distinguished it from sands belonging to the Upper Eocene, Marine Miocene, and non-Marine Miocene. The results of the mineralogical study is given in another publication (Shukri and El Ayouty, 1956).

b) Lava Flows.

A basalt flow, 25 m thick, is present at the western side of the present area. This is overlain unconformably by the Marine Miocene (Photo 6). Similar outcrops are recorded at the same stratigraphic position in numerous localities along the Cairo-Suez District (Barron 1907, Shukri 1953 *a* and *b* and Shukri and Akmal 1953) and in the Western Desert (Beadnell 1902). In the district between Gebel Ataqa and El Galala El Bahariya, to the south-east of the area under discussion, similar basalt flows are present (Sadek 1926). Andrew (1937) also referred to the basalts of the Cairo-Suez District and gave a review of the previous literature. Barthoux referred very briefly to the basalts of the present area as the basalts « north of Tower 9 » (1922).

Two main outcrops of basalt are present, with some smaller patches scattered in the area between them; the latter exposures are too small to show on the map. It seems that the small patches represent the remnants of a larger flow which must have been eroded away. Magnetic survey of the area shows that the basalt might be present beneath the Miocene and later sediments for a small distance to the east and north east of the main exposures. In the rest of the area, no « covered » lava flows could be detected by magnetic study. Very few small lava flows are present, as far as the author are aware, to the east of the area

mapped, the main flowes of the Cairo-Suez District being situated to the west, northwest and south-west. A large basalt outcrop occurs south of the area mapped, at Gebel Tireifya (Lat. 29° 58′ N., Long. 32° 04′ E.). This flow is present along the sides of an elongated semicircular graben, surrounded by Middle Eocene limestones from all sides except at its northern side, where Upper Eocene sandy limestones and marls with abundant *Carolia placunoides* are present. Only a part of this exposure is recorded on Barron's map. The mechanism of the emission of the basalt at Gebel Tireifya is comparable in many ways to the mode of origin of ring dykes.

The basalt flow in the Iweibid-Gafra area is mostly compact and dark, though occasionally pale green. It is sometimes weathered into spheroidal onion-shaped structures which are exfoliated. Some basalts are amygdaloidal; the amygdales being filled with quartz, chlorite and calcite. Very thin veins of quartz and calcite are frequently present, cutting the lava flow at a later stage.

Under the microscope, the main minerals of the basalt are labradorite, augite and magnetite. The former two minerals are frequently present in two generations. The structure varies from porphyritic to ophitic and sub-ophitic. The ground mass is made mainly of magnetite, with some augite and labradorite laths. The pyroxenes and plagioclase are frequently altered by hydrothermal action, giving such secondary minerals as chlorite, haematite and sausurite. Occasionally, the alteration is so intense that the original mineralogy is difficult to discern.

A study of the basalt of Gebel Tiereifya showed that it is microscopically similar to that of the Iweibid-Gafra area.

The basalts of the area east of Cairo (Shukri 1953 *a*) and of the area of Gebel El Anqabiya (Shukri and Akmal 1953) are compared with an olivine basaltic magma type.

3. Miocene.

Along the Cairo-Suez District, the Miocene rocks always occupy the topographic lows relative to the Middle Eocene.

The Miocene sediments in the present area are divisible into two : marine beds rich in fossils of definite Miocene age and fluviatile sedi-

ments which correlate well with beds in other areas of the Cairo-Suez District, also of Miocene age, and will be referred to as « non-Marine Miocene».

The Marine Miocene overlies the « Oligocene» with a minor unconformity. On the other hand the Miocene is transgressive over older rocks in the Gulf of Suez and Red Sea regions; it overlies unconformably the Middle Eocene in the Sudr Oilfiels on the east coast of the Gulf, the Cretaceous in Ras Gharib, the Carboniferous in Hurgada, the latter two oilfields lying on the west coast of the Gulf of Suez and the Red Sea and it overlies the basement rocks in Shadwan Island and the Esh Mellaha range. The Miocene is recorded by Sadek (1926) to be transgressive over the Middle and Upper Eocene to the north west of El Barabir, also situated on the western side of the Gulf of Suez.

The Marine Miocene section increases in thickness from west to east in the district between Cairo and Suez; it is 30 m thick in the area east to Cairo (Shukri 1953 *a*), 61 m in the area of Gebel El Anqabiya and Gebel El Nasuri (Shukri and Akmal 1953) and 80 m thick in the present area.

The non-Marine Miocene in the area of Gebel Iweibid-Gebel Gafra represents a facies that is completely different from that in the Gulf of Suez and the Red Sea regions. While the upper part of the Miocene is mostly represented in the latter areas by the thick lagoonal series of Evaporites, it is represented by non-marine detrital series in the area.

It seems that while the Gulf of Suez and Red Sea regions were areas of continuous deposition of evaporites at the close of the Miocene in the graben area, the northern part of Egypt in the latitude of the Cairo-Suez District was one of nearly continental conditions through uplifting.

a) Marine Miocene.

Directly above the « Oligocene» gravels (and or above the basalt), about 80 m of sands, sandy limestones and marls with occasional shales are present. Towards the base, sandstones are abundant, which are differentiated from the underlying sandstones of the Oligocene by the

presence of *Scutella* fragments. The lower beds of the Miocene are occasionally conglomeratic and gravelly. The sandy beds are not, however, confined to the lowermost part of the section; several sandy intercalations are found throughout. This vertical variation in the sediments may be explained by changes in the environmental conditions of deposition due to oscillation of the sea bottom.

The Marine Miocene is very widely spread in the area. It is present around the Middle Eocene, Upper Eocene and Oligocene exposures, either in faulted or normal contacts. To the west of the area under discussion, it extends in a conspicuous long ridge. There is also a small outcrop of Marine Miocene in the neighbourhood of Gebel Himeira to the south of the Cairo-Suez Road, in the south eastern corner of the area.

Occasionally, quartzite dykes cut the Marine Miocene beds along fault planes. In more than one locality both the Marine and the non-Marine Miocene beds are darkened and « silicified». This is significant with regard to the age of silification which has been the subject of disagreement between Blanckenhorn and Barron. According to Blanckenhorn (quoted from Barron 1907, p. 68), « the thermal springs belong to three periods, viz : Oligocene as in Bahariya etc., Lower Miocene but not sharply marked off from the first, and Pliocene». Barron, on the other hand, rejected the possibility of Pliocene silicification in the district between Cairo and Suez and confined the phenomenon to the Oligocene. He attributed the silicified trees found in the « Lower Miocene» to derivation from pre-existing trees in the adjacent Oligocene (*op. cit.*, p. 68). The writers are of the opinion that silicification in this area continued in post-Miocene times, as evidenced by the silicified sands and gravels along fracture planes of Marine Miocene and non-Marine Miocene age.

The Marine Miocene is rich in fossils and contains many oyster beds. The lower sandy beds are especially rich in echinoids, mainly *Scutella* and to a less extent *Clypeaster* spp. These beds are impoverished in, and sometimes completely devoid of oysters. The marly and more calcareous beds, on the other hand, are rich in them.

The most abundant fossils in the Marine Miocene are the following (after Said and Yallouze 1955).

PELECYPODA :

Anomia burdigalensis, A. ephippium.
Ostrea edulis, O. fimbriata, O. frondosa, O. (crassostrea).
gryphoides var. *gingensis. O. lamellosa, O. vestita.*
Alectryonia plicatula, A. plicatula var. *virleti.*
Pecten acutecostatus, P. cristato-costatus, P. fraasi, P. ziziniae.
Flabellipecten burdigalensis, F. expansus.
Chlamys sub-malvinae, C. zitteli.
Indoplacuna miocenica.
Paphia vetula.
Venus cf. aglauna, V. cf. burdigalensis.
Clementia ungeri.
Pectunculus (axinaea) cf. pilosus.
Spondylus crassicata. S. defrancei.

GASTROPODA :

Turritella terebralis, T. distincta.
Conus mecarti.

ECHINOIDEA :

Psammechinus aegyptiacus, P. paraetoniensis.
Echinolampus amplus, E. hemisphericus.
Clypeaster fakhryi.
Scutella ammonis, S. stefaninii.
Loevinia aegyptiaca.

A composite section in the marine Miocene in the area of Gebel Iweibid is given below, starting from the top.

Meters		Total
12	Yellow sandy and gritty limestone, occasionally with thin marl intercalations with *Ostrea lamellosa, Echinolampus* sp. and pelecypods........	12 meters
7	Sands and sandstones with thin intercalations of marls	19 meters
6	Sandy limestone, yellow and yellow brown with *Ostrea lamellosa Echinolampus amplus* and *Venus burdigalensis*...............	25 meters

4	Sandy marls, grey to pale green........................	29 meters
9	Sands and sandstones, dark to pale brown, occasionally cross bedded, marly towards the top with *Pecten cristato-costatus* and *Scutella* chips..	38 meters
14	Sandy limestone with thin intercalations of marls and gritty limestone : *Ostrea frondosa, Pecton frassi, Flabellipecten burdigalensis, Echinolampus amplus, Balanus* sp.................	52 meters
4	Sandy limestone with *Alectryonia plicatula virleti* and *Scutella* chips...	56 meters
10	Massive, white, chalky limestone rich in *Ostrea frondosa O. gingensis, Indoplacuna miocenica, Psammechinus paraetoniensis, Clypeaster hemisphericus* corals and pelecypods............	66 meters
10	Marls, pale green, occasionally sandy with *Clypeaster fakhryi, Ostrea frondosa, Alectryonia plicatula virleti* and *Scutella stefaninii*.	
4	Sands and sandstones with *Scutella stefaninii* and *Clypaster fakhryi*..	30 meters

Samples from the shaly beds in the area were examined for their foraminiferal and other micro-fossil content, but unfortunately yielded none.

According to Said and Yallouze (1955), who examined the fossils collected by the authors, the section seems to be one palaeontological unit that belongs to the Vindobonian. These two authors states that «the age of the Marine Miocene rocks of the Cairo-Suez District has been the subject of much controversy which has been summarized by Picard (1943) and Shukri and Akmal (1953). Picard refuted the presence of any genuine Burdigalian fossils in the assemblage, although he puts also the possibility that many of the forms have their start in the Upper Burdigalian and pass into Vindobonian (1943, p. 46); Shukri and Akmal agreed on estimating the age of the rocks as Middle Miocene (1953, p. 249). All fossils recorded in the area of Gebel Iweibid are either typical Vindobonian fossils or fall into such a long range of time as to be of little use in contributing an answer to this problem. The only exception to this is *Indoplacuna mioconica* (Fuchs) known from the Lower Miocene rocks of India, Burma and Sind. Since this form is a strange element in this typically Mediterranean fauna, its appearance in the Vindobonian is explained as a survival of an earlier migration in a new habitat or to homotaxy.

The Gebel Iweibid fauna is certainly Mediterranean in aspect although the presence of *Indoplacuna miocenica, Clementia ungeri* and some echinoids suggests a temporary and late invasion from the Indo-Pacific.

The faunal assemblage is composed mainly of a variety of Oysters, Pectens forming in some instances beds, with gastropods, corals, pelecypods, echinoids and bryozoa. The assemblage suggests an environment of shallow water shelf deposit of tropical to subtropical waters. The limestone facies suggests clear water conditions on the bottom, while the sandy facies with another characteristic assemblage suggests more turbid waters with more wet weather carrying the detritus» (*op. cit.*).

In two more recent works carried out by Sawaya on the western side of the Gulf of Suez at Gebel Gharra (north-east of Gebel Iweibid) and by Shata on the eastern side of the Gulf [1] Miocene sediments older than the Vindobonian were recognized. Sawaya identified microfossils that are at least as old as the Burdigalian, if not older; Shata collected macrofossils of marine Upper Oligocene or Oligo-Miocene age at El-Zeita, a locality nearer to the graben, and Tromp previously reported a 100 m thick marine section of grey clays and marls in the Socony Vacuum Wadi Dara Well, north of Gebel Zeit, to which he assigned an « Oligocene» age (1951, p. 81). It seems that a southern extension of the Upper Oligocene or Oligo-Miocene sea was restricted to the Gulf area and to the deeper parts of the graben. This sea seems to have transgressed westward at later times in Lower Miocene (Burdigalian) times (Gebel Gharra) and still farther west in Middle Miocene (Vindobonian) times (present area and Anqabiya). The visualized Oligocene or Oligo-Miocene Gulf is probably the later manifestation of the Carboniferous Gulf described by Said and the Senior author (1955) that has been repeatedly rejuvenated along the same trend through geological times.

b) Non-Marine Miocene.

Above the Marine Miocene, some 20 m of sands, grits and gravels are present. The gravels usually cover the outcrops giving them the

[1] Personal communication.

appearance of dark small hillocks, similar to those of the Oligocene hillcoks described above. The gravels of the non-Marine Miocene are, however, smaller in size and lighter in colour as compared with those of the Oligocene. The non-Marine Miocene sands are cemented by calcareous material, in contradistinction with the loose Oligocene sands or its quartzites. Again the fragments of fossil wood present in the non-Marine Miocene are nearly always of smaller size than those occurring in the Oligocene, and large fragments are rarely present. The Miocene gravels and sands contain also a heavy mineral assemblage different from that of the «Oligocene» (Shukri and El Ayouty, 1956).

No fossils other than the fragmentary fossil wood have been found in these sands and gravels and their age cannot therefore be exactly fixed. Sadek (1926, pp. 77-78), however, described similar beds with fresh water fossils (*Buliminus* and *Planorbis*) in the district between Gebel Ataqa and Gebel El Galala El Bahariya to the south-east of the present area, and attributed them to the Upper Miocene. In the area of Gebel El Anqabiya and Gebel El Nasuri, to the south west of the present area, similar formations to those present in the area of Gebel Iweibid were found to be separated from the underlying Marine Miocene and the overlying Pliocene beds by unconformities, and were described as non-Marine Miocene age (Shukri and Akmal 1953, pp. 247-248).

At the vicinity of Tower 12, Barron (1907, pp. 52-54) described «a small area of sands, conglomerates and clays» under the heading of «Beds of Doubtful Age», a locality which lies in the south eastern corner of the present area. He described a number of fossils which, according to Blanckenhorn, could place the sediments into the Middle Miocene (Helvetian). However, Barron put them in the Middle Pliocene. A close examination of this outcrop showed that it belongs to the non-Marine Miocene which is downfaulted against the Marine Miocene in that locality.

The gravels and grits to the west of Gebel Himeira to the south of the Cairo-Suez Road previously considered as Pliocene by Barron are here attributed to the non-Marine Miocene.

Some gypsum outcrops, about 5 m thick, were recorded to the east of the fault in the eastern part of the area (F_6). This outcrop is designated in the accompanying geological map as? non-Marine Miocene. This gypsum has no counterpart in the western part of the Cairo-Suez District and its significance is not fully understood. Whether it is actually an evaporite precipitated from a Miocene or a Pliocene lake is yet to be found out. In either case, it is interesting to interrelate these gypseous deposits with climatic conditions prevailing at the time of their formation. The wet climates that formed the fluviatile gravels and sands must have been followed by dry climatic conditions that caused the precipitation of the gypsum.

4. Pliocene.

To the north-west of Gebel Iweibid, a long strip of white polished limestones extends along the Cairo-Suez Railway line. No fossils were found in these beds which have a maximum thickness of 30 m. Samples examined for microfossils were also found barren. Sometimes gravels are present on the top of the series. The limestones in question is mapped as Miocene by Barron. The difficulty in determining the age of the beds lies in the fact that recent wash surrounds the exposures in the area, obliterating the relationships of these rocks with older formations. To the north of the West Iweibid anticline, however, non-Marine Miocene gravels were found to be overlain by similar polished limestones. Again similar beds in the Cairo-Suez Districts were considered by Sandford and Arkell (1939) and by Little (1925) as Pliocene. The Senior author and Akmal described comparable rocks that unconformably overlie the non-Marine Miocene at the area of Gebel El-Anqabiya and Gebel Al Nasuri, and also considered them as of Pliocene age (1953, pp. 246-247).

5. Recent.

Recent wash, made of sands and gravels, is present in the lowland around Gebel Iweibid topographic high and in all the wadis of the area. Middle Eocene boulders and pebbles are frequently encountered around the structure, especially along its northern side. Wind blown sands are also present along its southern side, especially in the central part.

B. SUBSURFACE

As will be mentioned later, Gebel Iweibid is an E.-W. structure that lies within the E.N.E.-W.S.W. trending lines of Syrian swells; the deviation from the normal E.N.E.-W.S.W. trend to an E.-W. one might be due to subsequent faulting that determined its present configuration. Along these Syrian lines of structural highs discontinuities in sedimentation are present, especially between the Cretaceous and Eocene; the pulsing movements responsible for them have been going on during a long lapse of time and more recently in pre-Upper Cretaceous to late Oligocene times (Shukri 1954).

At Gebel Ataqa about 200 m of Middle Eocene limestones rest unconformably over the Cretaceous (Lower Senonian-Turonian). At Gebel Shubrawit, 115 m of Middle Eocene limestones are present, unconformably overlying the Turonian. Similarly, an unconformity is believed to exist between the Eocene and older rocks in the area covered by this work as it is believed to have formed a part of a Syrian sweell. The length of hiatus represented in this unconformity is hard to estimate, since the degree of discontinuity of sedimentation on the highs within these lines of swells is known to be different in different places, depending on the magnitude of the movements which caused these structures, and the position of the locality relative to the highs (crest and flank) (*op. cit.*). Breaks as large as between? Oligocene and Upper Jurassic are known, as reported in the Anglo-Egyptian Oilfields (A. E. O.) Abu Sultan Well No. 1, some 35 km to the north of Gebel Iweibid or between Miocene and Jurassic as in the Socony Vacuum (S. V. O. C.) Uyun Musa Well No. 1, some 56 km to the southeast of Gebel Iweibid on the eastern coast of the Gulf of Suez. On the other hand, relatively smaller breaks are known as the one recorded between Upper Senonian (Maestrichtian) and Paleocene in Gebel Giddi, some 88 km east of Gebel Iweibid in Western Sinai.

If we assume that the movements responsible for the formation of Gebel Iweibid are of the same magnitude as those represented in the unconformity of Gebel Ataqa or that of Gebel Shubrawit (the nearest localities to the present area where unconformities are observed), the following could be a possible account of the subsurface formations.

1. Eocene and Paleocene.

Some 100 m of Middle Eocene are expected below the exposed section in the present area, as compared with the Gebel Mokattam (Shukri 1953 *a*), Gebel Ataqa (Shukri 1954) and Gebel El Galala El Bahariya (Sadek 1926 and Shukri and Akmal 1953).

The Lower Eocene and Paleocene are not expected in subsurface, as no such formations have been recorded in the neighbourhood and they are always missing on the structural highs which stood above the Lower Eocene and Paleocene sea levels.

2. Senonian.

Again the Upper Senonian is absent in Gebel Shubrawit and Gebel Ataqa and is not expected in subsurface at the present area. However, the Lower Senonian may be present, as the upper part of the section below the Middle Eocene at Gebel Ataqa may belong to the Senonian (Shukri 1954).

3. Turonian.

At Gebel Ataqa and Gebel Shubrawit, 360 and 150 m of Turonian massive limestones are present respectively. The formations at both localities are covered unconformably by Middle Eocene limestones. The Turonian section expected at the subsurface in the present area could be about 250 m thick.

4. Cenomanian and Nubian Sandstone.

At Gebel Ataqa, about 120 m of Cenomanian shales are exposed at the foot of the high cliff. The A. E. O. Ataqa Well No. 1 started in the Cenomanian and drilled about 175 m of Cenomanian and Nubian Sandstone. At Gebel Shubrawit on the other hand, about 300 m of Cenomanian, mostly shales, and about 400 m of Nubian Sandstone are present. A cautious estimation of the Cenomanian and Nubian Sandstone section anticipated in the subsurface in the present area is about 400 m.

5. Lower Cretaceous.

No Lower Cretaceous rocks were recorded, either in outcrop or in subsurface, in the vicinity of the area under discussion. Rocks of this age are not expected in subsurface here.

6. JURASSIC.

The nearest outcrop belonging to the Jurassic is the one at Khashm El Galala to the south east of the present area, where Sadek measured about 220 m (1926, pp. 34-37). However, thicker sections were encountered in the A. E. O. Ataqa Well No. 1 and the A. E. O. Abu Sultan Well No. 1, where 650 and 300 m were encountered respectively. A thick section of about 600 m is expected in the area of Gebel Iweibid-Gebel Gafra. The reduced thickness of Jurassic encountered in the A. E. O. Abu Sultan Well No. 1 may be due to more prolonged and intense denudation, since the Miocene with about 40 m of questionable «Oligocene» overlying unconformably the Jurassic in this well. The 600 m of expected Jurassic in subsurface compare well with the Jurassic isopach lines given by Shata (1951).

7. TRIASSIC.

Rocks of this age are exposed only in Areif El Naga in East Central Sinai, some 240 km to the north east of the area under discussion (Awad 1945 and Eicher 1947); the section at that locality amounts to 158 m. About 102 m of Triassic sediments were encountered in the Socony Vacuum Uyun Musa Wells and 83 m of sediments of the same age were drilled in the A. E. O. Ataqa Well No. 1. On the other hand, no Triassic is present in the wells of Abu Hauwash to the southwest of Cairo, drilled by the Standard Oil of Egypt (S. O. E.), in which the Jurassic rests directly on the Carboniferous. It seems that the Triassic sea did not reach that far west and that the area under discussion was covered for a short time and the section expected would probably not exceed 80 m in thickness.

8. CARBONIFEROUS.

No outcrops of Carboniferous age are known in the neighbourhood of the area mapped. However, a section more than 400 m thick is expected (the A. E. O. Ataqa Well No. 1 drilled about 400 m of Carboniferous), since the area of Gebel Iweibid-Gebel Gafra is believed to be farther away from the Carboniferous shore line as given by Said and the Senior author (1955) than the Ataqa well.

9. BASEMENT.

The Carboniferous always rests on the basement at all the localities where its base is exposed and in all the wells which passed the Carboniferous. Similarly, no pre-Carboniferous and post basement sediments are expected in the subsurface in the present area.

IV. STRUCTURE

A. REGIONAL

The structural pattern of the area under discussion and of the northern part of Egypt is mainly controlled by faulting of a dominant E.-W. trend (Mediterranean) and to a less extent by a N.W.-S.E. trend (Erythrean) responsible for the present direction of the Gulf of Suez and Red Sea graben. These faults affected the old folds of the Syrian lines of swells. This folding system involved a large number of domes and anticlines which extend from Syria south westward through Sinai, the Eastern Desert and Western Desert of Egypt. Some of these structures are exposed on the surface, such as the Abu Rauwash structure, Gebel Iweibid, Gebel Shubrawit and Gebel Moghara, whereas others are only known from geophysical surveys, such as the Abu Sultan gravity high.

Besides the Mediterranean and Erythrean trends referred to above, faults of a N.E.-S.W. (Aqaba) trend are also present but are not common, such as some of the faults bounding the northern side of Gebel Iweibid.

The relation between the three sets of faults, the Mediterranean, Erythrean and Aqaba trends, shows that any trend may merge into the other and none of the faults in the area displaces another and accordingly are all considered as being of the same age.

Different views have been put forward for the age of faulting. Blanckenhorn assigned a pre-Miocene age for the faults of the Cairo-Suez District in general (1901), but later on he agreed with Barron and assigned a «post-Miocene» age to the faulting (Barron 1907, p. 111 and Blanckenhorn 1921, p. 118); both authors did not attribute

different ages for different trends of faults. Sadek, on the other hand, made this differentiation when describing comparable faults in the district between Gebel Ataqa and Gebel El Galala El Bahariya, where he considered the N.W.-S.E. faults as of pre-Miocene age since « no evidence was obtained anywhere in the district to show that these latter rocks (i. e. Miocene) were themselves affected by them, « whereas the E.-W. trending faults are post-Miocene, since they affect rocks of all ages as far up as the Upper Miocene, i. e. « possibly of Pliocene age» (1928, pp. 113-114). Evidence obtained from the present work is in harmony with those obtained from other parts of the Cairo-Suez District (Shukri 1953 *a* and Shukri and Akmal 1953). The different faults are considered to be contemporaneous and as shown on the map they are post-Miocene and even later as they displace Miocene and later formations. Meanwhile the presence of a widely spread sheet of basalt below the Miocene in the present area as well as in other parts of the Cairo-Suez District connected with the faults shows evidence that the faulting is also of pre-Miocene age (Upper Oligocene). Evidence obtained from other parts of Egypt shows that the three trends are, as a matter of fact, as old as the pre-Cambrian and each of these trends together with a north-south trend played an important rôle in the determination of the structural pattern of Egypt through the ages (Shukri and Said—in preparation). The pre-Miocene faulting was rejuvenated in post-Miocene times, mainly along the old lines of fracture. Nevertheless the initiation of new lines of fracture in post-Miocene time could not be neglected, especially in the absence of positive evidence of older movements along the lines of fracture in question. The history of the Gulf of Suez and adjoining areas involves important tectonic incidents of faulting in post-Miocene times; it is hardly possible to conceive such important movements (faulting) to have taken place along old lines of weakness only, without creating new features. In this respect, the writers are partially in agreement with Barron's conclusion as to the post-Miocene age of faulting in the district between Cairo and Suez.

The flexures and undulations in the present area are mainly the result of faulting. The West Anticline and the South West Horst, for example, are bounded along their northern and southern sides by faults. The beds are nearly horizontal around the axes and they dip steeply at the edges due to drag movements along the fault planes.

The forces which created the structures in the area are most probably in the main tensional rather than compressional, and are not due to lateral contraction. This conclusion is based on the following observations :

a) Along the Cairo-Suez District (including the area in question) the faults are of the normal type; no thrust faults are recorded.

b) Some of the faults change their course and bend away from their original direction; at Gebel Tireifya, south of the area mapped, crescentic faults associated with basalt are present. It would be difficult to produce crescentic faults by lateral compression (which is expected to produce faults and folds more or less in one direction perpendicular to that of compression).

c) Similarly, faults of different trends more or less of the same age are difficult to account for by compression.

d) The area exhibits horsts, graben and step-faults both on a large and small scale, which are easier to explain by tension rather than by compression.

However, the Gebel Iweibid structural high is believed to have been initiated in pre-Oligocene time by the folding movements which formed the series of structures of the Syrian swells.

B. LOCAL

The main structure in the area covered by this work is Gebel Iweibid itself, which is a very conspicuous one in the district between Cairo and Suez. This structure is surrounded by several other structures which are smaller in size and are considerably lower in level. In the south eastern corner of the area the small Middle and Upper Eocene horst of Gebel Himeira is present. A syncline is believed to be present in the south eastern corner along the road between Cairo and Suez.

The structures of the area under discussion are shown by the 6 cross sections (Plate III) and the structural contour map (Plate IV) accompanying this work. Two beds are used in constructing the structural

contours : the top beds of the unfossiliferous series of the Middle Eocene (Gebel Iweibid and the South West Horst) and the base of the Marine Miocene. The anticipated irregular thicknesses of the Oligocene sands and gravels due to weathering made it unreasonable to project the Miocene contours to the datum line of the Middle Eocene unfossiliferous series. Furthermore, the structures in the Eocene and those in the Miocene and later times are considered in the present work to belong to quite different earth movements, both in time and type.

The following is a concise description of the main structures in the area.

1. Gebel Iweibid.

Gebel Iweibid is an E.-W. horst 9.5 km in length and 2.5 km at its widest part (Photo 1). It consists mainly of limestones and chalky limestones which become dark brown by weathering. The sides are steep and the dips are considerable at many points along the edges.

The horst is comprised between two faults (with a general E.-W. trend), which meet at the extreme eastern corner (F_1 and F_2 on the geological and structural contour maps). Some E.-W. faults were observed within the Middle Eocene mass itself, especially towards the north eastern side. The fault plane is most conspicuous on the southern side of Gebel Iweibid, where the downthrown beds are only visible along the eastern and western extremities whereas they are masked in the middle part by recent wash. Conditions along the northern side of Gebel Iweibid, on the other hand, are quite different. Most of the area to the north of the structure is covered by recent wash and Middle Eocene pebbles and boulders. It is not surprising, therefore, that this northern fault was missed by some previous workers. However, good small exposures of Upper Eocene sediments were found to be faulted against the Middle Eocene mass. These, together with the following observations, make it necessary to assume the presence of a fault which borders the northern part of Gebel Iweibid.

a) The Miocene beds lying to the north of the structure dip southward towards it; this excluded the possibility of the presence of an anticline with Gebel Iweibid mass as its core.

b) Along the northern side slickensided walls with fault breccia are recorded at some localities.

c) The Upper Eocene, Oligocene and Miocene beds to the west of the structure end abruptly (with marked change of dip and strike) along a line which is evidently a fault plane F_1 (Photo 2). This fault lies along a line which coincides in direction with the northern side of Gebel Iweibid and may be taken as an indication that it owes its presence to this fault.

The fault that bounds the western side of Gebel Iweibid in Barron's map (1907) was not verified in the present survey.

The closure on both sides of the structure is against a fault (F_1 and F_2). This structure has the best closure in the area. The structural contour map shows definite closure of the 290 m contour, with additional probable closure; the structural closure is at least 155 m.

2. The south west Horst.

This is an elongated wedge shaped horst structure of Middle Eocene, Upper Eocene, Oligocene and Marine Miocene rocks (Photo 2). It trends E.-W. and it is about 8 km in length and about 1 km in breadth at its widest part. The structure is partly bordered by boundary faults along the northern and southern sides. At the north western and southeastern edges the Upper Eocene overlies the Middle Eocene.

Closure along the northern side of the structure is against a fault and the attached structural contour map shows closure of the 200 m contour, with a structural closure of about 90 m.

3. The west Anticline.

This structure is in continuation with Gebel Iweibid in the east (Photo 3). It affects Marine Miocene beds and is bounded on both the northern and southern sides by faults. The drag along the northern fault plane, especially at its eastern part is conspicuous. The direction of the faults is also mainly east-west, corresponding to the main structural trend of the area, and the anticline seems to be due to faulting.

4. THE SOUTH ANTICLINE.

The structure runs parallel to Gebel Iweibid to the south and is faulted against the latter along the southern fault. It mainly affects Marine Miocene rocks, though some non-Marine Miocene gravels are present on the northern flank. The structure is interrupted by three faults, and shows no good closure.

5. THE NORTH-EAST ANTICLINE.

Only the western part of this structure was mapped. The core of this E.-W. trending anticline is Oligocene sands and gravels with Marine Miocene on both the northern and southern flanks.

6. THE CAIRO-SUEZ ROAD « SYNCLINE ».

In the south eastern corner of the area, north and north-west of Gebel Himeira, a « syncline » runs nearly parallel to the Cairo-Suez road. The southern « limb » of this structure is faulted against the northern side of Gebel Himeira. The « syncline » involves mainly Marine and non-Marine Miocene rocks. This « syncline » could probably be one that has come into existence by an E.-W. fault which runs along the « axis » of the structure in subsurface, towards which the beds on both sides are dragged. This was suggested by the preliminary magnetic survey of the area. The senior author and Akmal (1953, p. 262) explained the presence of nearly perfect minor domes and open noses in the Anqabiya and Nasuri area by supposing stresses acting in directions more nearly vertical than horizontal, such as would result from movements along old subsurface faults.

7. GEBEL HIMEIRA HORST.

This horst, not shown on the map, lies in the south eastern corner of the area covered by this work. It has a N.W.-S.E. trend, differing in that respect from all the structures described in this area, which trend east-west. The structure is bounded by two faults which meet together at the south eastern and north western corners. The horst consists of Middle and Upper Eocene rocks, the former being exposed at the north eastern part only. The down thrown rocks range from Oligocene to non-Marine Miocene. Previously, the Senior author and Akmal (*op. cit.*, p. 261) attributed the wedging of the Oligocene at the northern side of the structure to deposition on a pre-Oligocene high. In the present work, however, the wedging of the Oligocene gravels (and the marked thinning of the Marine Miocene in this vicinity) are accounted for by the presence of the boundary fault referred to. Two kilometers to the south of the Gebel Himeira Horst, the Middle Eocene plateau stands high along an east-west trending fault in continuation with the northern Ataqa fault.

8. FAULTS.

Faulting, as mentioned above, is the main structural feature of the present area. The following is a concise description of the main faults. Many of these faults are confirmed as well by the results of the magnetic survey which was carried on during the undertaking of the present geological survey.

F1 (*The North Iweibid Fault*).

The northern side of Gebel Iweibid is bordered by a number of disconnected faults, each starting where the other ends. This fault system ends at the eastern side where it meets the South Iweibid Fault, F2. The Faults change their course from E.-W. to N.W.-S.E. to N.E.-S.W. The « fault » extends for three km beyond the western end of Gebel Iweibid, and is some 15 km in length.

The faults of this system are normal and the fault planes are nearly vertical, hading slightly towards the down thrown side. Most of the formations of the down thrown side are masked by superficial cover that obscures almost all evidence of the presence of the fault. It seems that this fault was recognised by Barron (1907) on topographical evidence alone, since the Middle Eocene mass is mapped as standing boldly against the low land to the north, with no record or mention of the downthrown faulted blocks of Upper Eocene sediments. The several Upper Eocene patches recorded here for the first time along the northern side of the structure confirm the presence of the fault, and make it possible to calculate the displacement which amounts to at least 240 m. At the western extremity of the fault, the down throw is considerably less.

F2 (*The South Iweibid Fault*).

The southern fault is almost E.-W. in trend along its entire length of 9.5 km. It is also a normal fault with a very steep or nearly vertical fault plane; the hade is also towards the down thrown side. The middle Eocene beds towards the eastern end of this fault have dips as steep as 32° (Photo 4).

Along the southern side of Gebel Iweibid the down thrown formations are exposed along the eastern and western parts, whereas in the middle part they are obscured by wind-blown sands. The down thrown formations include non-Marine Miocene, Marine Miocene, Oligocene and Upper Eocene beds. Middle Eocene rocks are occasionally involved in the faulting. Intense silicification is noticed in the formations towards the east.

The displacement is not uniform along the entire length of the fault. The maximum displacement lies along the central part where non-Marine Miocene gravels are faulted against Middle Eocene with a displacement of 360 m whereas it is about 70-80 m along the western end of the fault, where Upper Eocene sediments are faulted against Middle Eocene.

F3 (*The South western Fault*).

This fault is about 16 km in length, the western 4 km of which are inferred on the map. It borders the South West Horst from the south. Along this fault, much silicification is observed; a quartzite dyke runs along the fault plane where the Marine Miocene is faulted against the Middle Eocene.

The fault plane is nearly vertical and takes more than one direction along its course ranging from N.W.-S.E. direction in the east and west to an E.-W. direction at the middle.

The maximum displacement is where the Middle Eocene is brought against the marine Miocene with a displacement of about 160 m. To the west the Upper Eocene is faulted against the Oligocene with a displacement of about 50-60 m. At the extreme western end, where the basalt is faulted against the Marine Miocene, the displacement is considerably less, being about 10 m only. It is, therefore, obvious

that the displacement decreases gradually from east to west, indicating that this fault is a hinge fault.

F4 and F5.

These two faults border the South West Horst along its northern side. Nearly at the middle of the structure the two fractures are in the form of two step faults. F4 affects Middle Eocene, Upper Eocene, Oligocene and Marine Miocene. F5 (particularly along its western part) affects Marine Miocene beds only, and is a hinge fault with a minimum displacement of 30 m and a maximum displacement of 120 m at its eastern extremity, whereas F4 seems to have a maximum displacement at its middle part with minimum displacement at both its eastern and western ends. This is also in harmony with a tensional origin of these faults, similar to major faults along the eastern side of the Gulf of Suez in which the maximum displacement is at the middle. F4 lies along the extension of the South Iweibid fault, F2, with a downthrow to the north.

Evidence of silicification, in the form of quartzite dykes, is present along these faults.

F6.

In the south eastern corner of the area under discussion, a N.W.-S.E. trending fault is present, which curves before reaching Gebel Iweibid to take an E.-W. direction. This fault brings non-Marine Miocene gravels against Marine Miocene with a displacement of about 30 m. Much silicification is believed to have taken place along this fault, since the formations on both sides of the fault plane are much blackened and «silicified». It extends south of the Cairo-Suez road and is about 5 km in length.

F7 and F8.

These two faults lie at the western end of the area. They trend N.W.-S.E. with displacements not exceeding 10 m. They comprise between them a minor graben. The eastern one of these two faults F7 might probably be the continuation of F3; this is confirmed by the magnetic survey.

V. GEOLOGICAL HISTORY

Egypt seems to have been a land mass during the major part of the Palaeozoic. Only in the Carboniferous the sea invaded the land mass. From the Carboniferous till the start of the Jurassic most of the country was again a land mass, with relatively thin sections of Triassic in very few localities (Areif El Naga, Uyun Musa and Ataqa). Jurassic rocks are well represented in Gebel Moghara, El Khabra and Nakhl in Sinai, Khshm El Galala, Ataqa and Abu Sultan in the Eastern Desert and in Abu Rauwash and Khatatba in the Western Desert. The Jurassic shore line may have been passing slightly to the south of these localities.

The Lower Cretaceous is represented by a small outcrop in Reisan Eneiza in Northern Sinai (Moon and Sakek, 1921). There are no records of Lower Cretaceous rocks in the Gulf of Suez area except that claimed to be present in Wadi Mellaha near the entrance of the Gulf of Suez graben by the A. E. O. geologists (Van der Ploeg, 1953). Sedimentation on a large scale, however, took place during Middle Cretaceous, Upper Cretaceous and Eocene times when the sea must have covered large areas of Egypt. Few breaks in the succession have been reported, and these are interpreted as due to lateral contractions which created some swells (the so called Syrian Swells) along which breaks were recorded as the sea retreated.

The Middle Eocene rocks represent deep sea conditions of deposition, whereas during Upper Eocene times the sea was shallower, as shown by the deposition of the more sandy deposits with abundant oysters.

The shallowing of the sea continued since the Upper Eocene times until the continental conditions of the Oligocene were established. Erosion of pre-existing deposits took place and the deposition of sands, gravels and wood fragments and trunks transported from the south took place. Towards the end of the Oligocene, basalt flows were brought up, which were followed by the emanation of hot fluids that caused the silicification of the wood fragments, trunks and the enclosing sands and gravels.

The last pulses of the lateral movements referred to above seem to have been at the close of the Oligocene, when Gebel Iweibid was raised as a fold structure with the Miocene sea surrounding it. In this respect, the writers are in agreement with Blanckenhorn's thesis (1921, p. 118) and not with Barron's as to the origin of the Gebel Iweibid structure, since the latter suggested that the structure was completely submerged by the Miocene sea (1907, p. 94). The emergence of the Gebel Iweibid in Oligocene times may be partly due to the late compressional forces that caused the formation of the Syrian Swells.

The Miocene basal conglomerates show that erosion seems to have taken place before the start of the Miocene transgression which must have been gradual as reflected by the lithology of the Miocene sediments. The lower Marine Miocene deposits are sandy and are difficult at some localities to differentiate from the underlying Oligocene sands, except by the presence of Scutella chips in the former. The deepening of the sea is reflected in the presence of limestones and marls on the top. The development of thick evaporite series in the Gulf of Suez and the Red Sea region towards the close of the Miocene shows that the region referred to become a closed basin at that time, indicating that the Gulf of Suez and the Mediterranean were disconnected; lagoonal conditions were established in the Gulf whereas fluviatile conditions prevailed in the northern part of Egypt, where complete regression of the sea and deposition of non-Marine sediments such as gravels, sands and grits took place. This episode of regression must have initiated movements that are responsible for the flexures and faults in the area of Gebel Iweibid-Gebel Gafra. These faults must have been mainly due to tensional forces. Later, silicated waters flowed along some of the faults forming quartzite dykes and continued to rise in Miocene and later times as evidenced by the silicification of their sediments.

Important faulting continued in Pliocene and later times along what seems to be older lines of fractures. The faults associated with the basalts in the western part of the area mapped, and which were initiated in late Oligocene time, affect Miocene beds as well. Those Pliocene movements seem also to be tensional and are responsible for the formation of horsts and step faults.

VI. OIL POSSIBILITIES

No oil shows have ever been reported in the district between Cairo and Suez, except for a questionable one reported by the South Mediterranean Oil Company (which was searching for oil in Egypt till 1945) to the south-east of Cairo (east of Maadi).

Nearly all the oil companies which operated in Egypt, however, made geological and geophysical studies (magnetic and gravity) in the district, but only one well was drilled at its very eastern extremity, namely, the A. E. O. Ataqa No. 1. This well was put down at the foot of the northern scarp of Gebel Ataqa, on the upthrown side of an E.-W. trending fault which brought the Miocene against the Cenomanian. Another well, to the far north east of Gebel Iweibid, the A. E. O. Abu Sultan No. 1, was drilled on a gravity high. Both wells were abandoned as dry holes. All operating companies have now concentrated their activity in the district bordering the Gulf of Suez and Red Sea Graben, where oil is present in commercial quantities and where all the Egyptian oilfields are present. The Iweibid-Gafra district is condemned as one of meagre oil possibilities on account of the absence of the sediments assumed to be the source and cap rocks of the Gulf of Suez and Red Sea oil (the Miocene Globigerina Marls and the Miocene Evaporites respectively).

Oil shows, however, have been recorded in some wells outside the Graben area, where the Miocene Marls and Evaporites are entirely absent. In Abu Rauwash Well No. 1 in the Western Desert (drilled by Standard Oil of Egypt S. O. E.) oil shows were reported in the Cenomanian, Lower Cretaceous Nubian Sandstone and Jurassic; bituminous shales were abundant in sediments of the Jurassic in this well. In the S. O. E. Darag Well No. 1 in Central Sinai, shows of oil were encountered in the Upper Turonian and Cenomanian. Again, shows were reported in the S. O. E. Nekhl Well No. 1 and Abu Hamth Well No. 1, also in Central Sinai, in the Cenomanian. Moon and Sadek recorded several oil-impregnations and smell of hydrocarbons in the Cretaceous, especially in the chalk and Cenomanian (1921, pp. 111 and 136-137). Similarly, P. Van der Ploeg reported that «the chalk series of Upper Cretaceous and the Eocene have been found to be slightly bituminous all over Syria, Western Jordan, Israil and Sinai» (1953, p. 157). This shows that oil of pre-Miocene age is probably present.

Owing to the fact that Miocene source beds and cap rocks are absent in the area, Miocene oil is not expected west of the Gulf area. If oil is present, it will be in older rocks and in structures quite different from the relatively younger structures in which the oil of the Gulf area is trapped, especially as basalts were emitted during the formation of these younger structures. Possible source rocks are present in the Jurassic and Carboniferous, where thick sections of shales, sometimes black and bituminous, are present, as those encountered in the wells of Abu Rauwash, Abu Hamth and Darag. Considerable thicknesses of these formations are expected in the district between Cairo and Suez northwards *vide supra,* which would furnish possible source. It was, however, disappointing that the S. O. E. El Khabra Well No. 1 drilled in north eastern Sinai in a thicker pre-Miocene section and on a good surface and gravity high, was a dry hole. Again, the Abu Rauwash, the Abu Hamth, Nakhl and Abu Sultan wells referred to above, though some of them encountered some oil shows, were all dry holes. The question of the presence of oil in commercial quantities having its source from pre-Miocene sediments in Egypt is yet to be proved. In this connection, it is to be mentioned that the prospects in the northern part of the Libyan Desert, now undertaken by the Conorada Oil Company (The Egyptian American Oil Co.) and the northern part of the Nile Delta is a much better prospect than the Cairo-Suez District. This is not only due to the greater thickness of sediments expected in the subsurface farther north, but is also due to the bigger structures present in them in pre-Miocene formations.

Though the cap rocks of the Miocene Evaporite Series are absent in the Cairo-Suez District, yet other sealing rocks such as the shales and marls belonging to the Cenomanian, Santonian and Paleocene, and the massive and compact limestones of the Turonian are present. Meanwhile, very thick sections of sealing cap rock are

9·

not needed to furnish an efficient barrier. It should be recalled to in this respect that the oil of the Burgan Field in Kuwait is capped by about 100 feet of shale (Lees 1953, pp. 69-71). In the newly discovered Belayim Field on the western coast of Sinai, oil was found in the uppermost part of the Miocene Evaporites, just below a thin cover (30-40 feet thick) of anhydrite which represents the weathering surface of this series.

The E.N.E.-W.S.W. trending structures of the Syrian Swells could furnish favourable accumulation sites for oil, particularly those hidden in subsurface with considerable sedimentary cover. It might be argued that the top Cretaceous-Eocene erosional period which affected unevenly the folds referred to could have caused the escape of any oil in the Cretaceous or older rocks, by removal of the cap rock. However, it is not necessary that erosion have proceeded as far as removing all the cover above the oil. A striking example of this is the Burgan anticline in Kuwait which, according to Lees « was folded by the Upper Cretaceous movement and subsequent erosion removed a substantial thickness of Senonian and Turonian shales. At the crest maximum of the dome, only about 100 feet of cap rock shales remained, protecting the oil sand from erosion and from escape of their oil richness» (*op. cit.*, pp. 69-71).

It is always mentioned that oil seepages are not commonly known outside the Gulf of Suez and Red Sea Graben, and hence the Western Desert and Northern Egypt were condemned as poor possibilities of oil. The writers believe that the abundance of surface seepages in the Graben region is mainly a reflection of the acute faulting it suffered, the region being dissected by a large number of faults of the same age as the oil bearing formations or slightly younger; this increases the chances of the presence of deep « cracks» along which oil seeped out of its reservoirs. In the areas away from the Graben region, however, conditions are different : the faults are much younger in age than the rocks in which oil is possibly trapped, and they might be mainly superficial, without reaching the oil levels. Surface oil seepages not only indicate the presence of oil in a certain area, but could also represent its last remnants, if seeping continued for a long time. Furthermore,

abundant oil seepages might be due to the proximity of oil from the surface; it is significant in this respect to mention that the deepest oil production in Egypt (Belayim and Feiran) are not connected at all with any surface seepages.

Reservoir rocks are not rare in the area under discussion. Sandstones are abundant in the Carboniferous and Lower Cretaceous (Nubian Sandstones) and in the Jurassic. Possible structures will be furnished by a fault relation between the source and reservoir rocks.

It should be mentioned that the areas away from the Graben region did not receive enough attention, since all companies were attracted to the Gulf area. About 140 wildcats were drilled in Egypt; only 15 of these were drilled in the areas outside the Graben region, notwithstanding the fact that the Graben District constitutes only about 1 % of the entire area of Egypt. This shows that the geological subsurface conditions of these vast territories are not sufficiently known to be considered unattractive.

The above discussion shows that the district between Cairo and Suez in general is not as unattractive with regards to oil possibilities as some geologists believe. Some more detailed geophysical studies are needed to locate subsurface structures. This applies as well to the area of Gebel Iweibid-Gebel Gafra, in order to locate any of the pre-Miocene structures that are now covered by the post-Oligocene formations. The Gebel Iweibid structure itself has a good closure and is in this respect better than the Anqabiya-Nasuri structure, but it is much faulted and for this reason may not be promising.

VII. SUMMARY AND CONCLUSIONS

The present work deals with the geology of the area of Gebel Iweibid-Gebel Gafra (an area of 300 square km) which lies some 45 km to the north-west of Suez. A geological map of the area on the scale of 1 : 25.000 was made (which is reproduced here to a scale of 1 : 50.000). The only available somewhat detailed map of the area is that of Barron given in his Cairo-Suez geological map on a scale of 1 : 250.000.

The formations recorded range from Middle Eocene to Recent, and the succession is as follows :

	Thickness
RECENT	
Pliocene	+30 meters
—— Unconformity.	
Non-Marine Miocene	20 meters
—— Unconformity.	
Marine Miocene	80 meters
—— Unconformity.	
Basalt	25 meters
Oligocene	
Sands and Gravels	+45 meters
—— Unconformity.	
Upper Eocene	63 meters
Middle Eocene	+200 meters

Several unconformities are recorded. The Oligocene has unconformable relations with both the overlying Miocene and the underlying Upper Eocene beds. The Marine and non-Marine Miocene are separated by an unconformity. The Miocene fossils are mainly Mediterranean, with the exception of some forms which suggest a temporary and late invasion from the Indo-Pacific. In nowhere in the area studied (and in the district between Cairo and Suez in general) the Miocene is transgressive on the Eocene or older beds. This observation contrasts with the Miocene relations in the Gulf of Suez and the Red Sea regions, where it may be directly transgressive over the pre-Cambrian.

On the eastern side of the Gulf of Suez the marine beds overlying the continental Oligocene are of Oligo-Miocene age whereas they are Burdigalian at Gebel Gharra on the other side of the Gulf (Shata and Sawaya [1]) and are of Vindobonian age still farther west. This may be taken to indicate that the sea in the Gulf of Suez graben gradually transgressed westward, covering the Gebel Gharra area in Lower Miocene times and the Gebel Iweibid in Middle Miocene times. The presence of only one Lower Miocene fossil, *Indoplacuna miocenica* (Fuchs) at Iweibid and the presence of Vindobonian fossils only at El Anqabiya farther west is

[1] Personal communication.

also indicative of this westward transgression of the sea in later times.

The structural features of the area are mainly due to faulting. Two main trends are present, an E.-W., which is more prominent, and a N.W.-S.E. one. An occasional third trend with a N.E.-S.W. direction is noticed. Most of the faults are of post-Miocene age, though those associated with the basalts are considered to have been initiated in late Oligocene times.

Gebel Iweibid itself is a horst block of Middle Eocene rocks; some smaller horsts and faulted anticlines formed mostly of Miocene sediments are also present.

The area in question was affected mainly by two earth movements, one of folding due to lateral compressive forces that ended in the early Oligocene and another of faulting due to tension in late Oligocene and later times. The early Oligocene lateral compressive forces represent perhaps the last pulses of the movements responsible for the formation of the Syrian lines of swells. By this folding action, Gebel Iweibid stood as a positive area in the transgressing Miocene sea. This folded block was then broken along both its northern and southern sides by the later faulting that occured in Miocene and post-Miocene times.

The Cairo-Suez District has not been seriously affected by the tectonic movements of the Gulf of Suez region; the structures of the two districts are nearly perpendicular to each other in trend and direction.

The sediments expected to be present in the subsurface of the area were discussed, and the following subsurface section was drawn from a study of the regional geology of the area :

Middle Eocene	+100 meters
Turonian	+250 meters
Cenomanian & Nubian Sandstone	+400 meters
Jurassic	+600 meters
Triassic	−180 meters
Carboniferous	+400 meters
Basement	

The geological history of the area was discussed. The area was subjected to folding that continued in pulses till early Oligocene times, as shown by the recorded unconformities within the Cretaceous and Eocene formations along the so-called Syrian Swells. The Middle Eocene

sediments that are the oldest formations exposed on the surface in the area show deep sea conditions of sedimentation while the overlying Upper Eocene shows evidences of the shallowing of the sea. This shallowing culminated in the prevailance of continental conditions and the deposition of the older « Oligocene» series of gravels and sands. Near the top of this continental series the area was affected by severe faulting which caused the emission of an olivine basaltic magma type on a large scale, and that was followed by late magmatic action (Shukri 1953 *b*). This was followed by a new transgression of the Miocene sea that first covered the graben area of the Gulf of Suez and then progressed westward away from the graben. Gebel Iweibid itself was an island in the Miocene sea as also were the highs extending from Gebel Tura to Gebel Ataqa farther south. The Marine Miocene sediments were accordingly not deposited on these highs. This contrasts with the thick Miocene deposits of the Red Sea and Gulf of Suez regions. The development of thick evaporite series in the latter regions towards the close of the Miocene indicates that they became separated from the open sea (the Tethys) to form a closed basin. Lagoonal conditions were established in the graben area of the Gulf whereas fluviatile conditions prevailed in the Cairo-Suez District especially at its western part where complete regression of the sea and deposition of the newer non-Marine Miocene gravels and sands series took place. The association of gypsum with these newer non-Marine Miocene gravel series may indicate precipitation from a mass of water during a period of aridity.

The hydrothermal fluids and hot springs that caused the silicification of the transported wood and the enclosing sands and gravels was continued in post-Miocene times as evidenced by the presence of quartzite dykes and silicified beds in the Miocene, especially in the vicinity of faults. This conclusion is in agreement with Blanckenhorn's study (1921) and is different from Barron's idea of assigning only an Oligocene age for the silicification (1907).

The Pliocene period is marked by further faulting along what seems to be the old lines of movements and by the deposition of unfossiliferous porcellaneous limestone, the significance of which is still to be known.

The oil possibilities of the Cairo-Suez District, and that of the northern part of Egypt are discussed. Pre-Miocene oil shows are present, particularly in Jurassic and Cretaceous rocks and the possibility of these rocks as source rocks is emphasized. Reservoir rocks might be abundant in the Carboniferous and Lower Cretaceous (Nubian Sandstone) and in the Jurassic. The E.N.E.-W.S.W. trending structures of the Syrian swells could furnish favourable accumulation sites for oil, while faulting may produce favourable conditions for bringing in contact source and reservoir rocks. No wells have been drilled in the Cairo-Suez District and detailed geophysical work is needed before any conclusion could be made. The presence of considerably thicker section of sediments along the northern part of Egypt makes that part more promising with regards to oil possibilities than the district between Cairo and Suez. The Gebel Iweibid structure has a big closure but the presence of faulting on a large scale may diminish its oil possibilities. It is yet to be seen by drilling the ultimate oil potentialities of the district [1].

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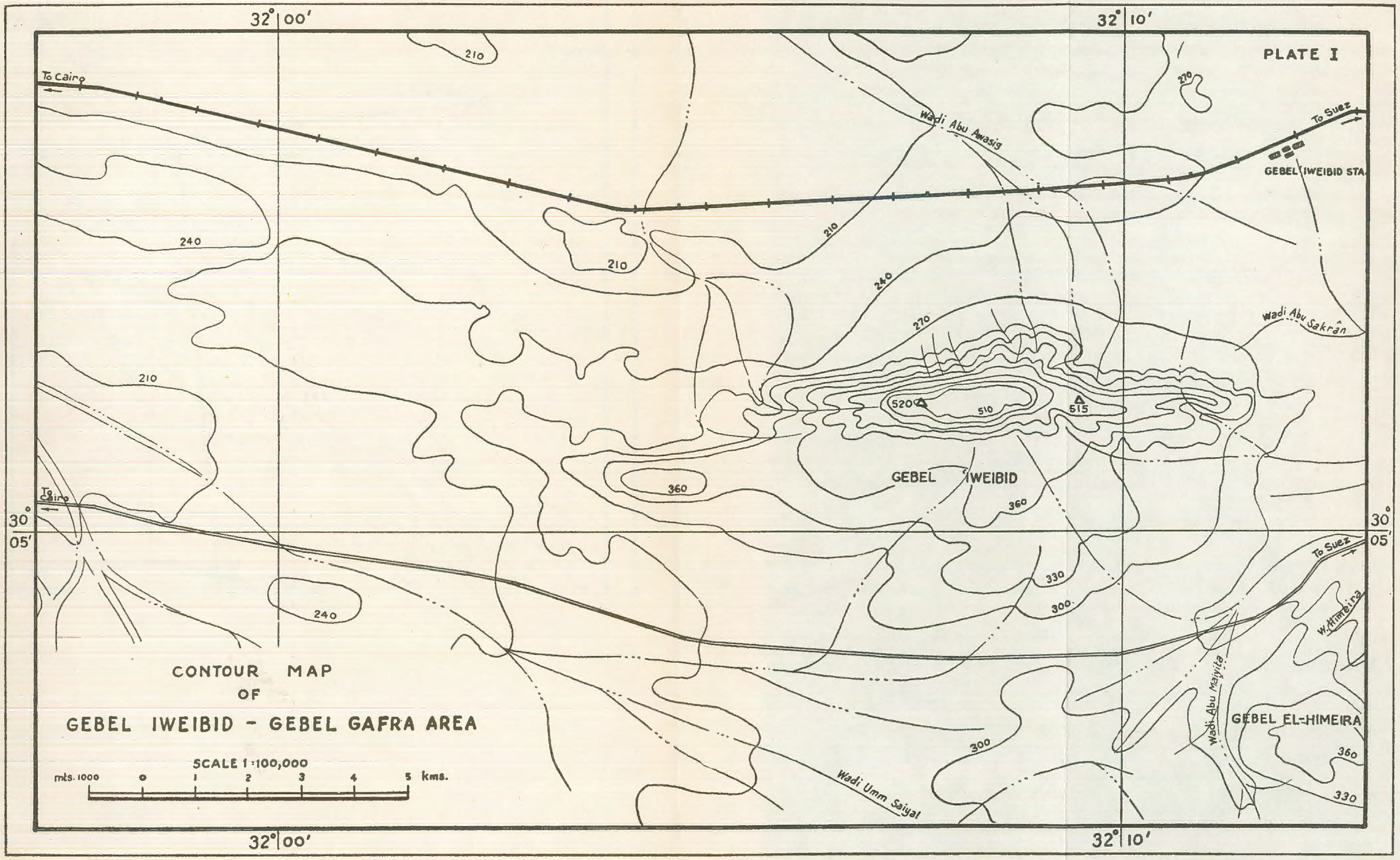


PLATE I
32° 00'
32° 10'
30° 05'
To Cairo
To Suez
GEBEL IWEIBID STA.
Wadi Abu Awasis
Wadi Abu Sakrân
GEBEL 'IWEIBID
520
510
515
360
330
300
270
240
210
Wadi Umm Saiyal
Wadi Abu Maiyita
W. Himeira
GEBEL EL-HIMEIRA
CONTOUR MAP
OF
GEBEL IWEIBID - GEBEL GAFRA AREA
SCALE 1:100,000
mts. 1000 0 1 2 3 4 5 kms.

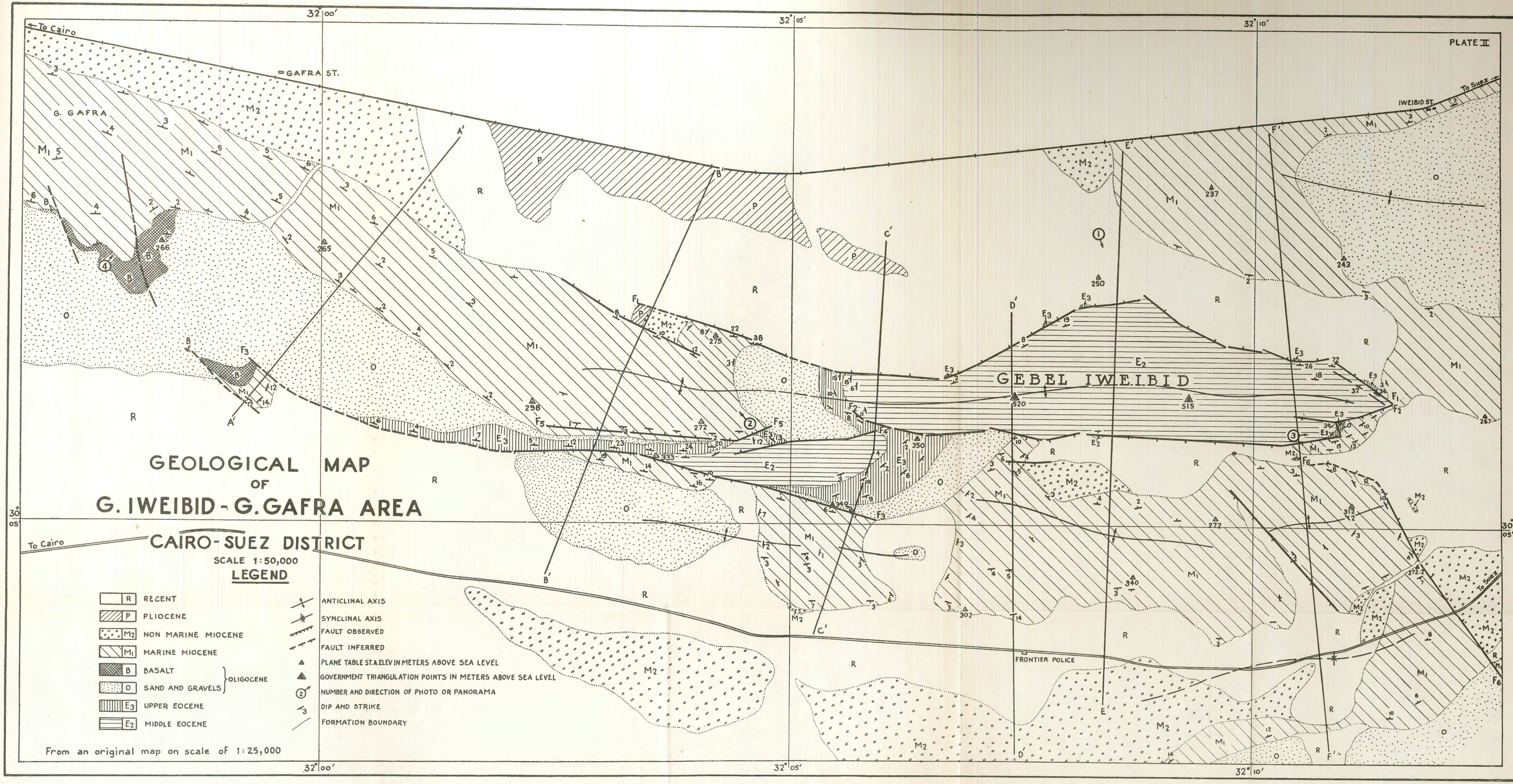


PLATE II
GEOLOGICAL MAP
OF
G. IWEIBID - G. GAFRA AREA
CAIRO - SUEZ DISTRICT
SCALE 1:50,000
LEGEND
R RECENT
P PLIOCENE
M2 NON MARINE MIOCENE
M1 MARINE MIOCENE
B BASALT
O SAND AND GRAVELS
OLIGOCENE
E3 UPPER EOCENE
E2 MIDDLE EOCENE
ANTICLINAL AXIS
SYNCLINAL AXIS
FAULT OBSERVED
FAULT INFERRED
PLANE TABLE ST. & ELEV. IN METERS ABOVE SEA LEVEL
GOVERNMENT TRIANGULATION POINTS IN METERS ABOVE SEA LEVEL
NUMBER AND DIRECTION OF PHOTO OR PANORAMA
DIP AND STRIKE
FORMATION BOUNDARY
From an original map on scale of 1:25,000
GEBEL IWEIBID
G. GAFRA
GAFRA ST.
IWEIBID ST.
FRONTIER POLICE
To Cairo
To Suez
32° 00'
32° 05'
32° 10'
30° 05'

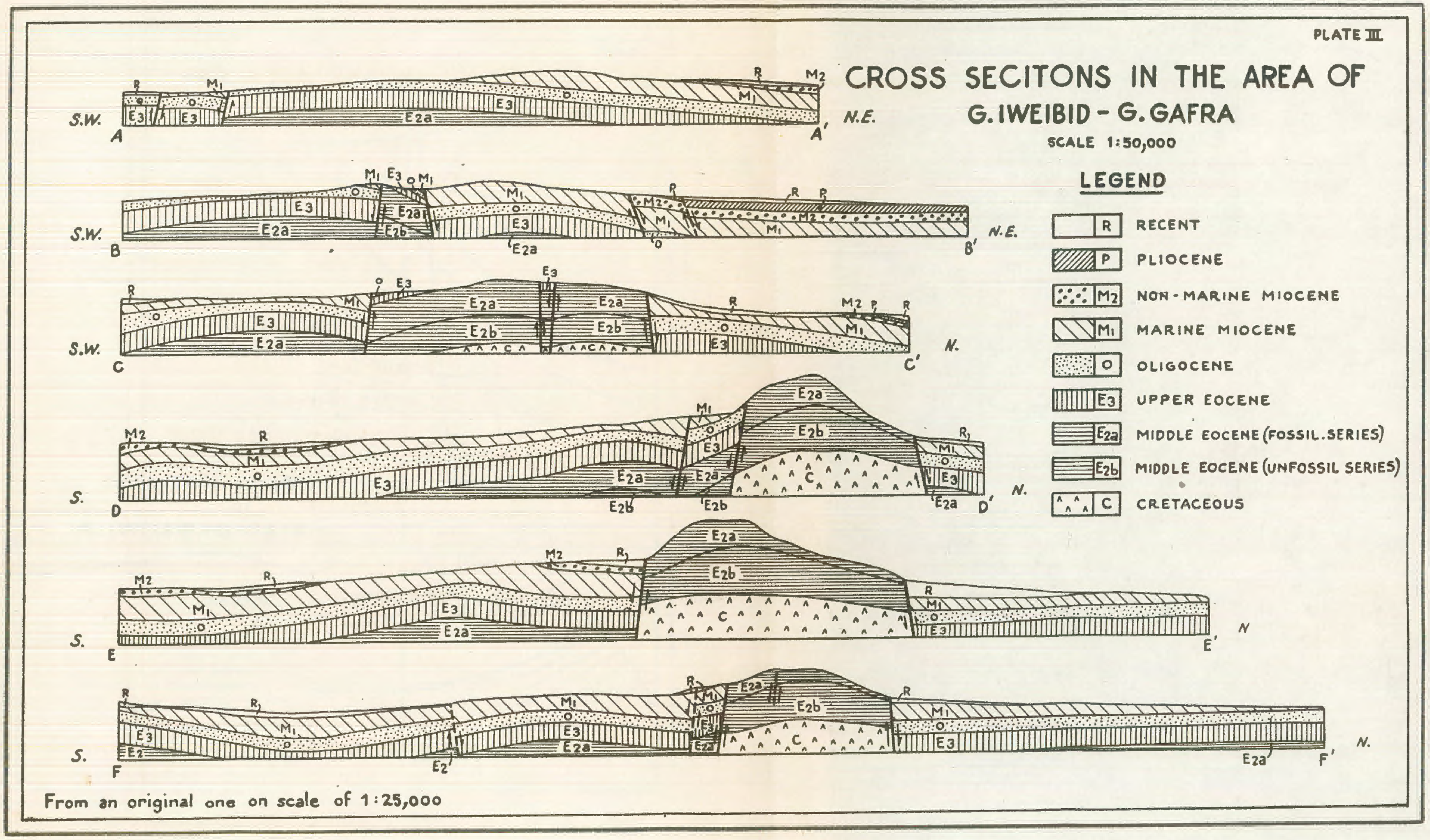
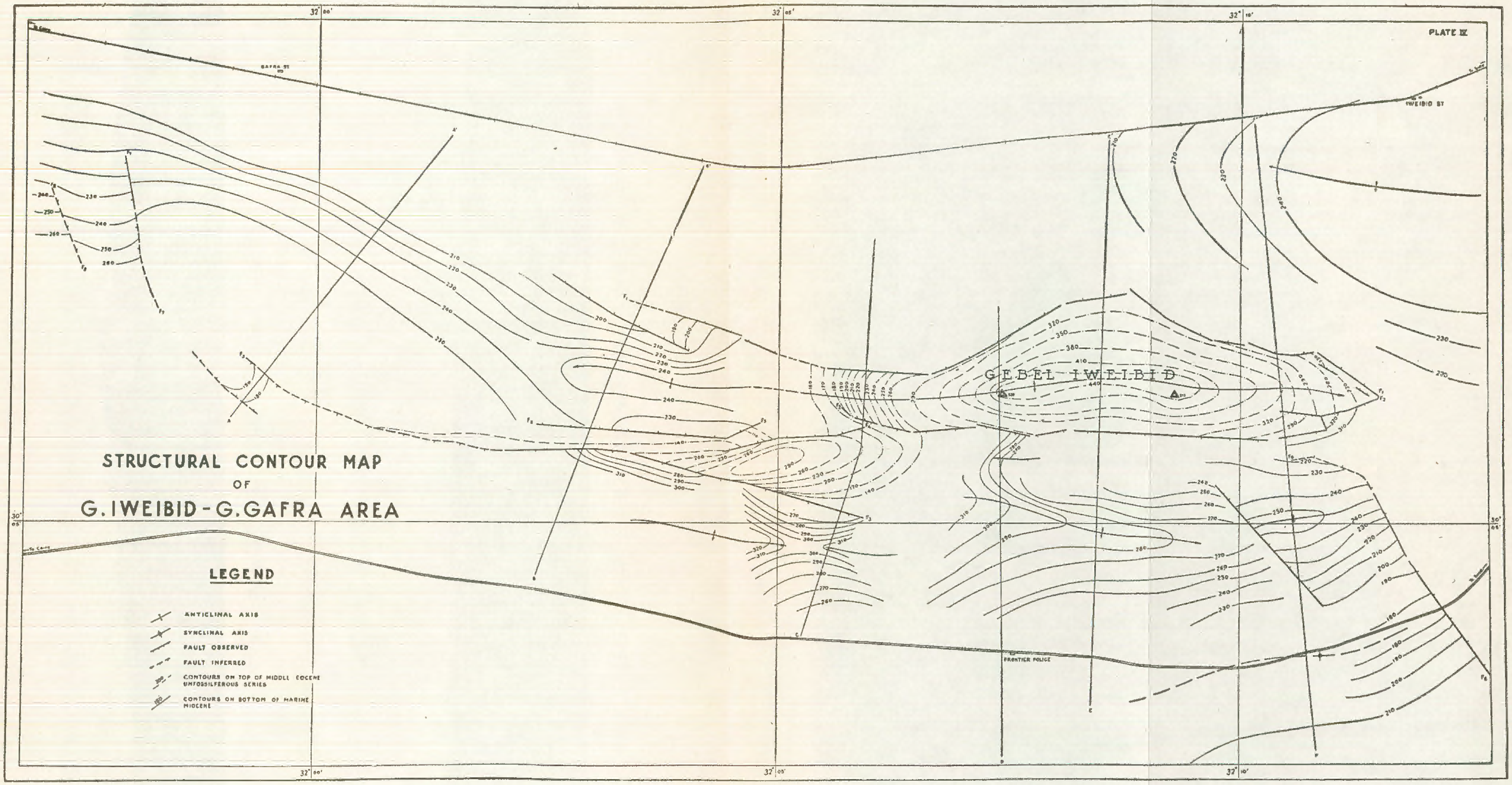


PLATE III
CROSS SECITONS IN THE AREA OF
G. IWEIBID - G. GAFRA
SCALE 1:50,000
LEGEND
R RECENT
P PLIOCENE
M2 NON-MARINE MIOCENE
M1 MARINE MIOCENE
O OLIGOCENE
E3 UPPER EOCENE
E2a MIDDLE EOCENE (FOSSIL. SERIES)
E2b MIDDLE EOCENE (UNFOSSIL SERIES)
C CRETACEOUS
S.W.
N.E.
A
A'
B
B'
C
C'
N.
S.
D
D'
E
E'
F
F'
From an original one on scale of 1:25,000



Scale 1 : 100,000, from an original one on scale of 1 : 25,000.

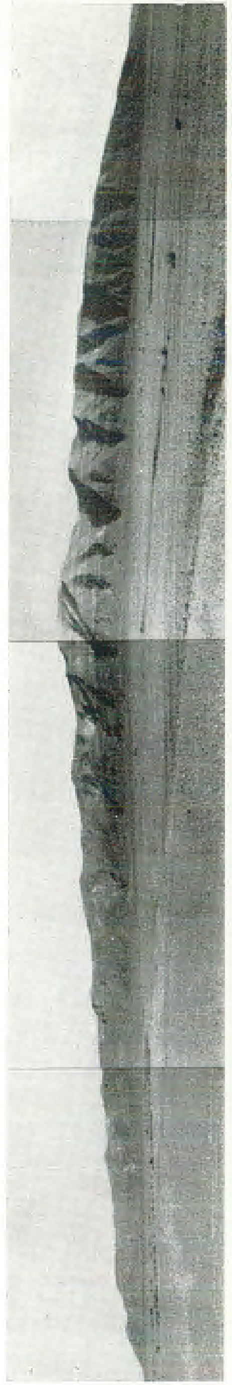


Photo 1. Gebel Iweibid. Northern Side.

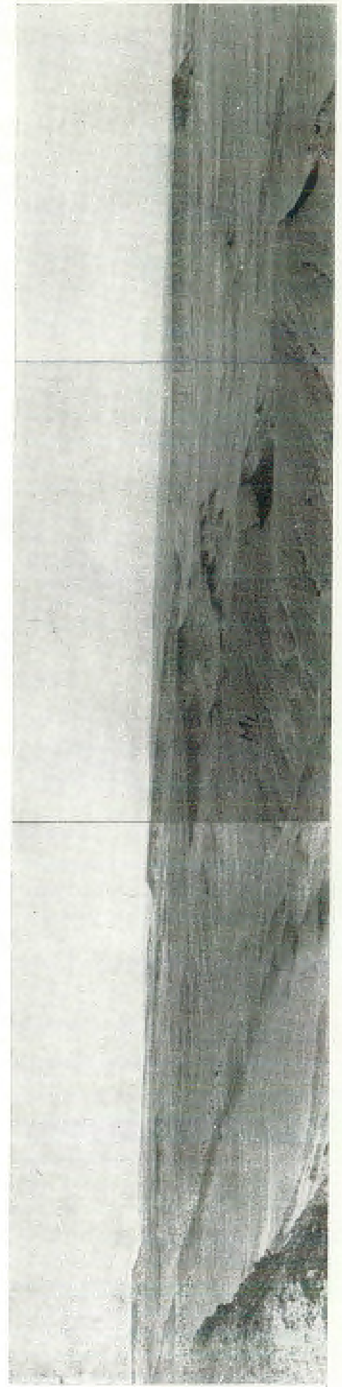


Photo 2. Photo showing the West Anticline within Marine Miocene sediments.

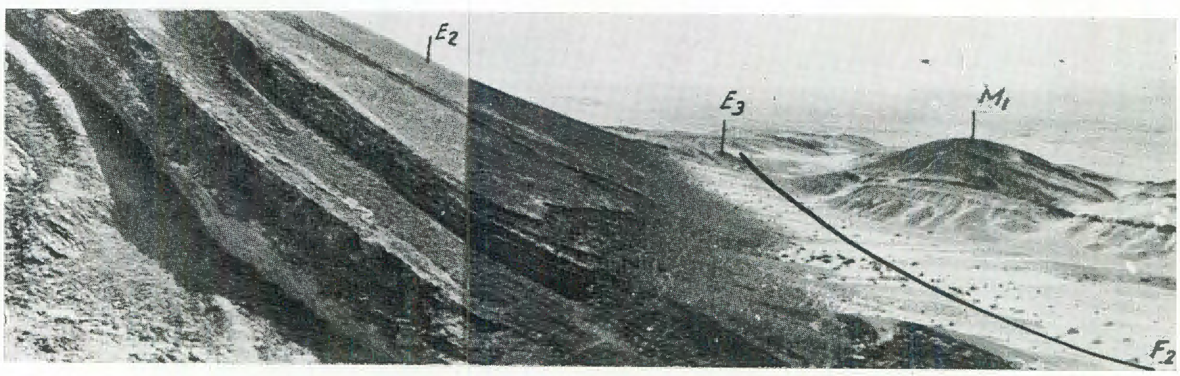


PHOTO 3. Showing Southern Fault (F_2) of Gebel Iweibid down throwing Marine Miocene (M_1) against Upper Eocene (E_3) and Middle Eocene (E_2). Notice steep dips in Eocene due to drag along the fault.

PHOTO 4. Panorama showing part of miniature graben. Basalt (B) is overlain by Marine Miocene (M_1). Another basalt outcrop, not shown in photo is present to the right.

OUTLINE OF A NEW GEOLOGICAL THEORY

BY

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INTRODUCTION

The puzzling problems of mountain building (orogenesis), uplift and subsidence of continents (epirogenesis), and volcanic activity in the widest sense (volcanism and plutonism) have been treated by geographers, structural geologists, stratigraphers, volcanologists, petrologists and geophysicists, but in most cases, the problems were considered in the light of each one's particular specialisation. There is no doubt, however, that all phenomena of dynamic and physicochemical geology are so linked together that no single process can be really understood and logically explained, unless it is studied as a constitutional part of a general frame, so that its function in the very complicated geological machinery can be grasped. The aim of theoretical geology must be the construction of this frame in the form of a comprehensive theory, and not the enunciation of numerous partial hypotheses which, in themselves, may seem satisfying, but when considered as a whole, afford partial incompatibilities.

Attempts of general geological theories have been undertaken by a great number of scientists. Some of them have been generally admitted at a time, such as for example Suess's theory of the thermal contraction of the earth, or Wegener's theory of continental drift. These two well known hypotheses, like many others, are characterised by the intuitive acceptance of models suggested by our daily experience and their application by reference to the scale of the earth without necessary criticism. The attractive appeal of picturesque comparisons, such as « the crumbling skin of a drying apple» (Suess) or continents that drift on the mobile

Sima « like icebergs in the sea» (Wegener), has surely contributed very much to the success of these hypotheses. So did also Argand's and Staub's conception of a rigid African Continent that overrides Europe, squeezing out the Mediterranean Geosyncline and thrusting nappe over nappe to build up the Alps. None of these authors really explains the origin of the forces that are supposed to cause the drift of the continents, or the mechanism of the tremendous deformation of the crust. The picture they expose is essentially a cinematic conception in which the dynamic events remain forcibly unexplained, being unexplainable, because such cinematic images which have been readily admitted are mechanically impossible.

In searching for plausible causes of the crust's deformations, Ampferer came to the conclusion that subcrustal currents in the magma must be at work, and this idea was later developed into many variations. Pekeris, Vening-Meinesz and other geophysicists admitted that convection currents are created within a thick homogeneous substratum as a result of the differential cooling of the earth, and Holmes suggested the existence of such subcrustal currents created by differential heating from radioactive processes. Kraus tried an explanation for the building of the Alps based on the cinematic picture given by Argand and Staub by admitting a sucking action of descending currents at that time and on those places where it was needed for the desired explanation.

Since nearly twenty years, the writer attempted to approach the problem from the opposite direction, i. e. starting from theoretical considerations the results of which were then checked by their possibility to explain the geological facts in a satisfactory manner [1]. The following is the English version of a general survey of the writer's own ideas and hypotheses, in which most geophysical and geochemical details are omitted, while some new facts and ideas, not yet published elsewhere, have been added.

[1] A. Rittmann, *Zur Thermodynamik der Orogenese,* Geol. Rundschau 1942;— *Vulcani,* attività e genesi, ed. EPSA, Naples 1944;— *Orogénèse et volcanisme,* Arch. Sciences phys. nat., Genève, 1951;—*Lectures held at Rome,* Stockholm, Uppsala, Lund, Paris, London, etc.

This attempt of coordinating the writer's own ideas with a great number of partial hypotheses has, naturally, a somewhat eclectical character. However, as H. Cloos has pointed out in 1942 with regard to one of the writer's papers : « in view of the complex relations of the problem and the height of its aim, the eclecticism of the procedure is surely not a sign of weakness but, on the contrary, a guarantee for its solidity».

Approach to the problem

An explanation has to be found for the causes and the reciprocal relations of orogenesis, epirogenesis and volcanism, in agreement with the data of geophysics and geochemistry, and with the principles of mechanics and physico-chemistry.

In order to coordinate logically the manifold facts and their temporal and spacial relations, we have to start from the well established principles of thermodynamics which, in the non-mathematical language of a geologist, may be enounced briefly as follows :

Any geological event is a reaction which tends to re-establish a static or dynamic equilibrium that has been disturbed.

Starting from this fundamental principle, we must, first of all, establish the sources of geological energies and the nature of geological equilibria. Then we have to state where these equilibria are established (or nearly so), and where they are disturbed. Any disequilibrium must originate forces which cause the geological events. We shall see that these forces often disturb other equilibria, producing thus chains of causes and effects, i. e. chain reactions which, finally, will re-establish all geological equilibria in a given region.

In proceeding in this manner, we shall get as a result of our considerations a schematic model of the geological mechanism. In order to apply this scheme to the actual phenomena, it will be necessary to discuss briefly the mechanical behaviour of the substance that constitutes the earth-crust and its substratum [1].

[1] Dealing here with orogenesis and volcanism, which are both processes of relatively shallow depths, the writer will not enter in discussions about the origin

The Sources of Geological Energy

Besides the well known sources of geological energy, such as gravity, rotation of the earth, tidal forces of the moon, radiation of the sun, inherited and radiogenic heat and chemical reactions, etc...., the degassation of the subcrustal magma must be considered to be a very important source of energy upon which volcanism and plutonism depend almost entirely. The term degassation is used here in its broadest sense, including not only the more or less explosive eruption of gases in active volcanoes, but also the diffusion or intergranular upward migration of volatile substances through the earth crust, occurring on a large scale in orogenic belts during mountain building, and thus producing allochemical metamorphism, granitisation, and even partial or total remelting of pre-existing rocks (anatexis), with all the related phenomena, among which the formation of economically important ore-deposits.

It has to be emphasized that the above mentioned sources of energy are sufficient to explain all geological phenomena, and that there is no

of the earth, the formation of its original crust, and the nature of its interior. Since 1940, W. Kuhn and the writer have published several papers on these subjects in which they admit and defend the hypothesis of a solar origin of the earth, in their opinion the only one that permits a satisfactory explanation of the actual state of the earth and of the nature of meteorites. They are hence in complete disagreement with C. Urey and the American school of planetesimalists. For details see :

W. Kuhn and A. Rittman, *Ueber den Zustand des Erdinnern und seine Entstehung aus einem homogenen Urzustand,* Geologische Rundschau 32, p. 215-256; 1941.

A. Rittmann, *Die prägeologische Pneumatosphäre und ihre Bedeutung für die geologischen Probleme der Gegenwart,* Experientia 3 (Heft 8), p. 1, 1947.

W. Kuhn, *Elektrische Aufladung einer Planetenatmosphäre bei hoher Temperatur als Ursache für selektiven Verlust leicht ionisierbarer Elemente, Verhandl. Naturf. Ges. Basel,* 59, p. 62; 1948.

A. Rittmann, *Zur geochemischen Entwicklung der prägeologischen Lithosphäre, Schweiz. Min. Petr. Mitt.* 28, p. 36-1948 (Niggli-Festband)

W. Kuhn and S. Vielhauer, *Analogieversuche zur Ausbreitung von Bebenwellen in einem homogenen Erdinnern,* Geochim. and cosmochim. Acta 3, p. 169-185; 1953.

need at all to invoke unknown « cosmic forces» or highly improbable nuclear reactions within the earth, as some authors have done in the past.

The Geological Equilibria

Let us mention briefly these equilibria and the necessary and sufficient conditions for their establishment :

Theoretically, the *gravitational equilibrium* at the earth's surface would be established only if the topographic relief were nil, i. e. if a panthalassa, a universal sea, existed, preventing gravitational transport of water and its denuding action. Practically speaking, we can consider this equilibrium to be established, in respect to the tectonical events, if the continents are peneplained.

The *hydrostatic equilibrium* is established, if the layers in and beneath the earth crust have constant thicknesses and lie horizontally.

Naturally, the *isostatic equilibrium* is established, if the hydrostatic equilibrium is; but the reverse is not true. It is evident that the isostatic equilibrium can also be realized if the thickness of the layers vary, and even if any of the layers wedge out completely, provided that the load on the surface of compensation is constant; in this case, however, the hydrostatic equilibrium is disturbed.

The *thermal equilibrium* is a dynamic one. It is established, if the geoisothermes coincide with geoidal levels. If this coincidence occurs at any given point within the earth crust, the temperature and the flow of heat remain constant, the latter being directed rigourously upwards.

Finally, the *physico-chemical equilibria* are realized, if, at any given point, substances occur in their stable phases and are in thermodynamic equilibrium with each other at the prevailing temperatures and pressures. Heterogeneous equilibria, like that between magma and gasses, are very sensitive to variations of pressure; such equilibria explain the mechanism of volcanic eruptions [1].

[1] See A. Rittmann, *Der Ausbruchsmechanismus des Vesuvs,* Naturwissenschaften, 22, p. 305-311, 326-329; 1934.

A. Rittmann, *Vulkane und ihre Tätigkeit,* Stuttgart, 1936 (new edition in preparation), Ed. F. Enke.

The fundamental Difference between Cratonic and Orogenic Regions

In most of the well known hypotheses, orogenic belts are said to be « weak, plastic or mobile» parts of the crust, in contrast with continents which are supposed to be « resistant, solid or rigid» massive shields. In reality, this contrast of mechanical behaviour does not exist. All hypotheses, based on this erroneous assumption, have to be discarded.

In fact, seismological and gravimetrical data prove beyond doubt, that continents are formed of thick layers of sialic materials resting on a simatic layer, while in the suboceanic crust the sialic layers are comparatively thin (Atlantic) or even missing (Pacific). In spite of this difference, both, sialic continents and simatic ocean floors, show the apparently «rigid» behaviour of cratons. Why then should orogenic belts, which are built up of the same sialic and simatic materials in various proportions, be less «rigid» than the cratonic crust? Specially, if one considers that the mechanical behaviour of rocks of sialic and simatic nature is nearly the same.

The fundamental difference between orogenic and cratonic regions must be looked for, in reality, in the light of the following facts :

Orogenic belts are tectonically active because, as a result of the irregular constitution of the crust along those belts, *some of the geological equilibria are disturbed,* thus developing active forces which, in their tendency to re-establish the equilibria, produce important tectonic movements.

On the contrary, *cratonic continental or suboceanic regions are tectonically passive, because* the constant thickness of the crustal layers and the smooth topography are causal factors *of the persistence of geological equilibria.*

In order to avoid any misinterpretation, it may be necessary to state that « tectonically passive» does not mean that no tectonic displacements can take place in the cratons, but that epirogenetic movements in the cratons are only secondary reactions to those tectonic events which occur in orogenic belts within and beneath the earth crust.

Thermal Desequilibrium and its Consequences

The geothermal gradient depends upon the quantity of heat which flows through the unit of surface per second, the conducibility of rocks, and the distribution of radio-active elements within the crust. From theoretical considerations, largely confirmed by experimental data, it is possible to establish within reasonable limits the above mentioned factors. The writer has carried out calculations based on average values, to determine the distribution of temperatures within the earth crust and in the uppermost parts of the substratum, the results of which are represented schematically in figures 1 and 2. The heavy line between the geo-isothermes of 1100 and 1200° C represents the average temperature of the melting interval of olivine-basalt under corresponding pressures. This line indicates what we may call the base of the crystalline crust, the thickness of which varies, according to the distribution of Sial, roughly as follows : (S = thickness in km.).

Cratonic region	Sial I	Sial II	Sima	Total crust
Normal continent	$S_1 = 20$	$S_2 = 25$	$S_3 = 25$	$S = 70$ km.
Pacific Ocean	$S'_1 = 0$	$S'_2 = 0$	$S'_3 = 31$	$S' = 31$ km.
Atlantic Ocean	$S''_1 = 9$	$S''_2 = 11$	$S''_3 = 37$	$S'' = 57$ km.

By admitting extreme values for the above mentioned factors, these figures vary only within about 20 %, but—and this is very important—in all calculated 14 cases, the subpacific crust proves to be much thinner than the continental crust (about 1/3 to 2/3). Furthermore, it is to be noted that the crystalline crust has no sharp base, but passes gradually into molten magma. Under surface conditions, basalts at 1050° C become sufficiently fluid for ready flow. This temperature, increased proportionally with pressure according to the law of Clapeyron-Clausius, has been chosen to indicate the base of the crystalline crust.

From the above figures it appears that along orogenic belts, i. e. in the transitional zones between the continental « high cratons » and the oceanic « low cratons» (Stille), geo-isothermes are more or less inclined in respect to the geoidal levels (horizontal in the figures).

The direction of flow of heat being perpendicular to the isothermes, forms hence an angle with the earth's radii, and a horizontal temperature gradient is consequently created. The normal thermal equilibrium is therefore disturbed, and so is the hydrostatic equilibrium, because, at any given level in the magma-zone the magma becomes hotter and lighter towards the Ocean. At a depth of about 75 km.

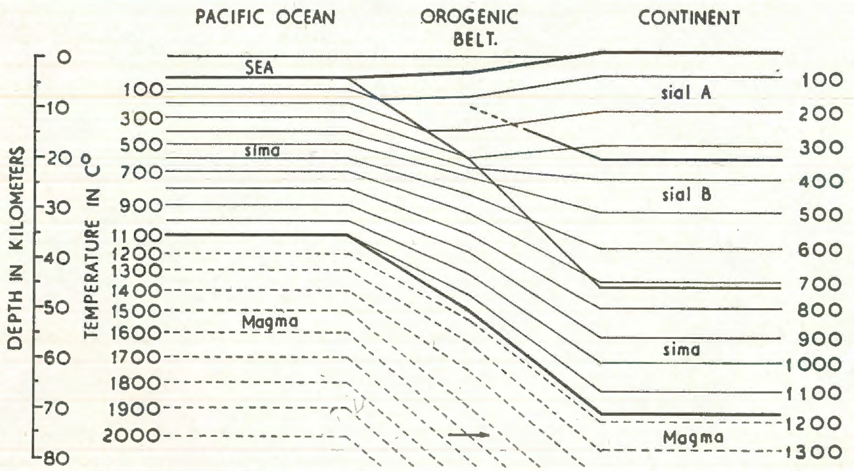


Fig. 1.

the temperature of the magma beneath the Pacific Ocean is about 700° C higher than that beneath the continent (see fig. 1). In the case of the Atlantic Ocean this difference of temperatures is only about 120° C (see fig. 2). Because of the presence of absorbed gasses, the thermal dilatation of the magma is so important that the difference of densities of the sub-oceanic and the sub-continental magma can easily exceed 0, 1, say at a depth of 75 km.

Mechanical Behaviour of the Subcrustal Magma.

Seismologists believe that the substratum of the crust is solid, and even, that the earth is solid till down to the depth of 2900 km. On the contrary, petrologists, volcanologists and physico-chemists declare that

the substratum is formed of molten magma, i. e. a liquid. Some remarks may be stated, to show that this contradiction is only an apparent one, caused by the improper use of the term « solid».

The magma must be defined as a silicate melt containing volatile substances in solution. Beneath the crust, at 1200° C and a pressure of about 20.000 atm. its viscosity is of the order of 10^{22} poises, as

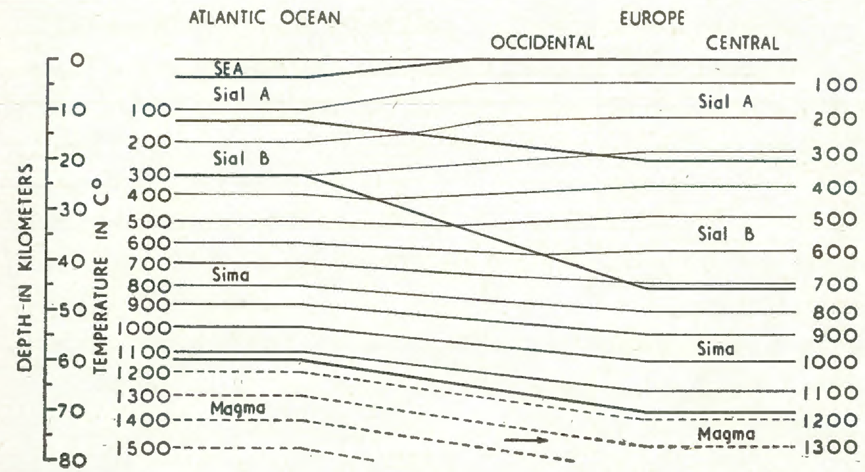


Fig. 2.

deducted from tidal and isostatic phenomena, and its modulus of torsion is about 10^{12} (seismic rigidity). According to Maxwell's relation (viscosity = rigidity × relaxation time), it must possess a relaxation time of 10^{10} sec at least. Against tensions that last less than the relaxation time, the magma behaves as an elastic solid body, as for example against earthquake waves with their periods of 2 to 50 seconds; but against long lasting stresses it reacts as a perfect liquid, as for example against forces set up by hydrostatic and isostatic desequilibria. In this latter case, the magma yields even to the least stresses by flowing, i. e. it reacts as a viscous liquid and not as an elastic medium.

Again, if shearing stresses are strong enough to accumulate a strain greater than the ultimate shear strength in a shorter period than the time of relaxation, the liquid magma will break, as if it were a solid

body, and a fault will originate. Such tectonic dislocations in the subcrustal magma produce the deep-focus earth-quakes.

Another extremely important property of the magma is the enormous drcrease of viscosity caused by release of pressure. In fact, the viscosity is an exponential function of pressure, and if, as a result of the formation of an abyssal tensile fissure, the pressure drops from 20.000 to a few atmospheres, the viscosity drops from 10^{22} to about 10^{5} poises, i. e. the magma becomes so fluid that it can penetrate immediately into the opening fissure and rise towards the surface. Furthermore, in the uppermost parts of the intruding magma, the bulk pressure will be lower than the vapour tension of the dissolved gasses, so that a gaseous phase must evolve. The evolving bubbles transform the magma into a foam which expands and rises with increasing speed along the fissure. Enormous quantities of basalt magma pour out during such fissure eruptions and cover wide areas. This explains the formation of the famous basalt plateaux of India, Columbia, Patagonia, Siberia, Iceland, Greenland, Arabia Abyssinia etc. [1].

Finally, the homogeneity of the subcrustal magma must be shortly discussed with regard to the question of convection currents. It has been said (van Bemmelen) that such currents are impossible, because the magma becomes inhomogeneous, being differentiated by density increasing with depth and thus preventing convection currents. In fact, a rather conspicuous increase of density in the earth's mantle has been ascertained by geoghysical data. However, the writer can not agree with the process of differentiation in subcrustal magma for two reasons : First, any effective gravitational crystal differentiation is impossible in a melt with such

(1) The low viscosity of the rising magma facilitates its gravitative differentiation during its ascent : in the transitional zone, at the base of the earth crust, the basalt magma contains many phenocrysts of olivine which are heavier than the melt. During the ascent, these crystals sink in respect to the melt, i. e. they rise slower and are accumulated at a certain distance beneath the magma level. According to circumstances, they may remain in the depth (dunites, peridotites), or they may be extruded after the olivine-free basalt (ultrabasic lavas, serpentines etc).

a high viscosity as that of the subscrustal magma. In the second place, the increase of density with depth can just be explained quantitatively by compression. In fact, as the compression lasts longer than the time of relaxation, the static and not the dynamic compressibility becomes efficient [1].

These and other facts lead us to the conclusion that subcrustal magma must be homogeneous right to the depth of 1000 or even 1200 km. For volcanological, geochemical and physico-chemical reasons, the writer is convinced that the composition of subcrustal magma corresponds to that of a highly olivine-rich basalt (« oceanite»), and not to that of dunite as believed by many geophysicists.

Impulsion and Dynamic equilibrium of Convection Currents

Convection currents must originate in the homogeneous viscous subcrustal magma wherever the thermal and hydrostatic equilibria are disturbed. We have already seen that such desequilibria exist beneath the marginal parts of the sialic shields and, especially, beneath a circumpacific belt. In those orogenic regions, the currents receive a continuous impulsion. An accelerated movement, directed towards the

(1) On the base of theoretical considerations, Kuhn and Rittmann have predicted in 1941 that the dynamic compressibilities, as determined in the lab or deduced from the seismic behaviour, must be smaller than those valid for compressions that last longer than the time of relaxation. In 1954, Kuhn and Vielhauer confirmed this hypothesis by demonstrating experimentally that there are in fact two types of compressibility of amorphous matter, a static and a dynamic one. They found that the static bulk modulus (k') is about 30 % smaller than the dynamic one (k). This very important discovery permits also to explain quantitatively the famous seismic discontinuity of first order at the so called core at 2900 km of depth, by a sudden decrease of the viscosity and the relaxation time, due to the collapse of the relatively complex silicate molecules at high temperatures and pressures in presence of considerable quantities of hydrogen. The hypothesis of Kuhn and Rittmann, which postulates the earth's interior to be constituted of somewhat degassized homogeneous solar matter, and not of an iron core, appears strongly supported by this new discovery.

continents, must originate there in the subcrustal magma. The impulsion dies out beneath the cratonic continent, where the geological equilibria are established. The currents encounter, there, passive masses, and get deviated obliquely towards the depth, under the continents. Thus the subcontinental magma undergoes compression, while, beneath,

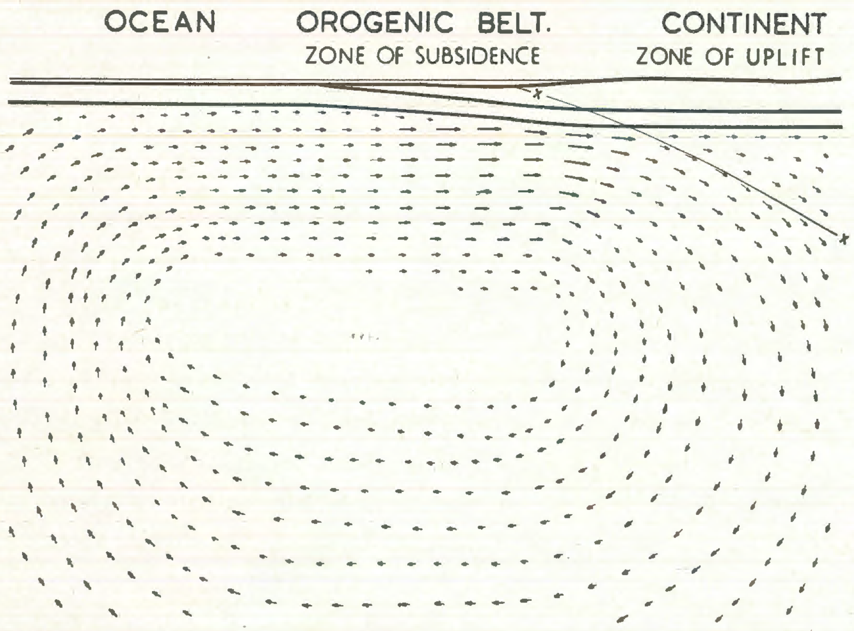


Fig. 3.

the orogenic belts, the accelerated flow causes suction and distension (see fig. 3).

Above the active zone of impulsion, the crust is stretched and therefore subsides because some magma is withdrawn in depth. This means a disturbance of the isostatic equilibrium, characterized by negative gravity anomalies. This disturbance creates forces that tend to reestablish isostasy by uplift. The greater the subsidence, the stronger wilbe the forces acting against it. Yet the subsidence has still another effect : causing the geo-isothermes to sink to depth, the horizontal thermal gradient lessens in the zone between the axis of subsidence and the

continent. Consequently, the forces, set up by the thermal and hydrostatic desequilibria and causing the subsidence, become weaker, while the forces that cause the isostatic uplift grow stronger, and vice versa. A dynamic equilibrium must result from the action of such interdependent opposite forces.

Origin and Nature of Marginal Deep-Sea Troughs

Approximate calculations show that the crust, at the axis of subsidence, must sink for about 6 to 8 km in order to establish the above mentioned dynamic equilibrium at the margins of the Pacific Ocean, i. e. deep-sea troughs of about 9 to 11 km will be formed. As they are the geomorphological expression of a dynamic equilibrium, they are stable features which will not change, unless quite an independant external factor disturbs the dynamic equilibrium. It is to be expected that an abundant sedimentation must be such an external factor. This is confirmed by the fact that all deep-sea troughs are situated at the margins of sialic shields, in regions, where a considerable sedimentation is impossible, either because the continent is partly submerged (East Asia), or because coast ranges constitute watersheds near the Oacean (Western America) [see fig. 4].

We have already seen that the crust is submitted to tensile stresses and that it undergoes stretching. If the stresses overcome the ultimate tensile strength, abyssal fissures originate, along which the subcrustal magma rises to the surface. Deep-sea troughs are therefore characterized by very active submarine volcanism. The volcanicity in recent deep-sea troughs remains mostly hidden, because the pressure of the overlaying water is greater than the critical pressure of the water vapour discharged by the volcanic eruptions, and because other volcanic grasses (HCI, Co_2, H_2S, H_2 etc.) are dissolved in or react with the sea water before they can reach the surface. Furthermore, the eruptions can not be explosive as they must be considered rather as sill intrusions between the deep sea and its bottom. The dead boiled deep sea fishes occasionally observed at the surface of the sea be the proof of the occurrence of such eruptions. A more direct evidence is

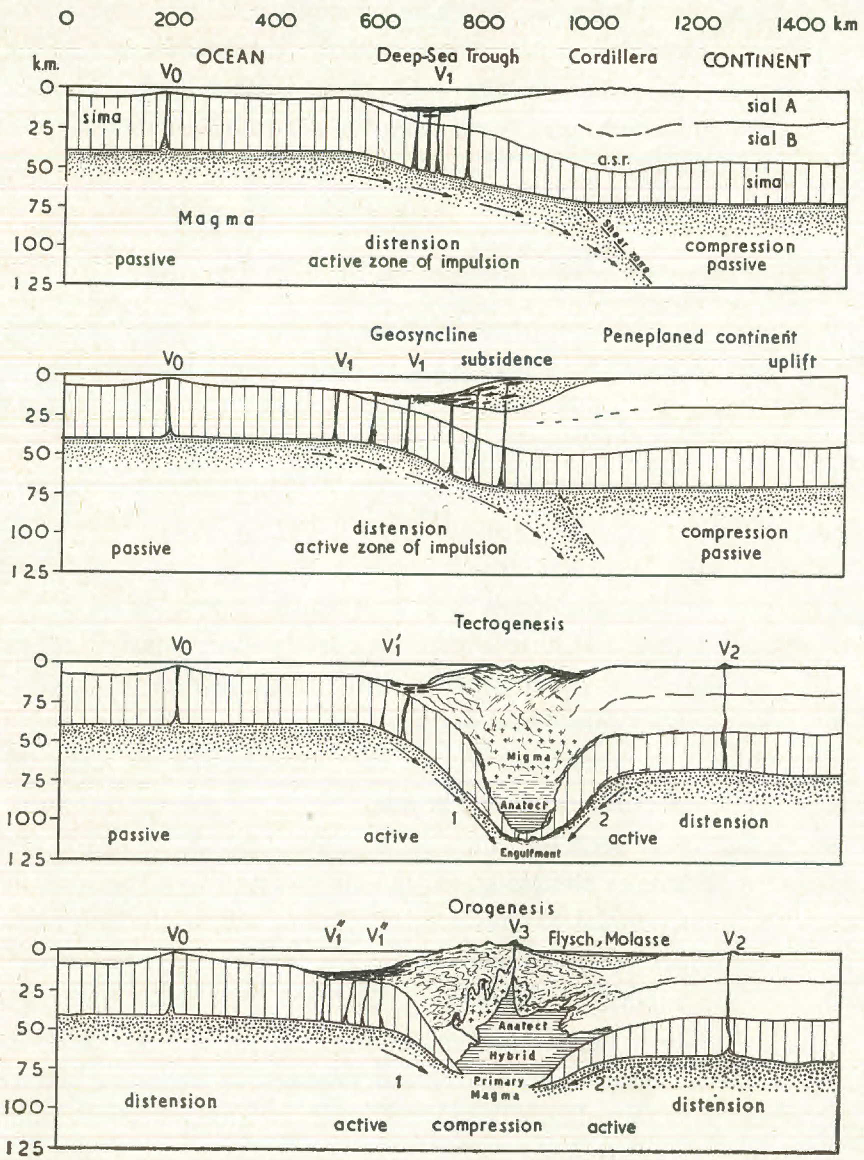


Fig. 4.

furnished by the occurrence of belts of basalts and serpentines associated with very little deep-sea deposits. These belts are clearly uplift deep-sea troughs of ancient geological periods, e. g. in the Eastern Desert of Egypt, in Anatolia, in the Balkans etc.

The Significance of Deep-Focus Earthquakes

A great number of earthquakes are known to have hypocenters which lie deep within the magma zone down to 700 km (Wadati, Gutenberg and Richter, Visser, etc.). The geographical distribution of these deep Foci is remarkable : They occur only in regions bounding the Pacific Ocean and are visibly associated with deep-sea troughs. They lie in zones that plunge obliquely beneath the continents.

Furthermore, it has been shown that they are due to tectonic movements, to faulting within the subcrustal magma. In figure 3, the line x-x indicates the zone of maximum shearing stresses due to convection currents. The fact that the foci of earthquakes are situated in the same zone, confirms the existence of convection currents of the type discussed above.

The Formation of Geosynclines

Any deep-sea trough is potentially a geosyncline. As soon as the coastal range has been peneplained, or as soon as an epirogenic uplift has transformed the sea-shelf into dry land, huge masses of sediments will reach the deep-sea trough and convert it into a geosyncline [1].

[1] Sedimentation can not be the primary cause of the formation of a geosyncline, but it will accelerate and increase the subsidence of the underlying crust. Let x be the thickness of the sediments, d their density (about 2.3), and D the density of the displaced subcrustal magma (about 3.3). The subsidence S' caused by the load of the sediments is then

$$S' = \frac{d}{D}\, x = \text{about } 0.7\, x.$$

As the facies of the geosynclinal sediments remains generally constant, the total subsidence S must be about equal to x. It results that about subsidence S must be about equal to x. It results that about 30 % of S must be due to the action of the subcrustal current. It has been stated that x can reach 20 to 25 km which corresponds roughly to S. Thus, 30 % of S = 6 to 7 ½ km, due to the action of the subcrustal convection current. Adding to these values the normal depth of the sea, one gets the depth of the deep-sea throughs which, in fact, lies between 8 and 12 km.

Abundant sedimentation upsets the dynamic equilibrium of the deep-sea trough and causes a chain of reactions that lead to the evolution of an orogenic cycle, the primary stage of which consists in the formation and the maturation of the geosyncline. Leaving aside, on purpose, all complications that may result from local conditions, the evolution of a geosyncline can be described as follows :

The subcrustal current produces compression beneath the continent, which is epirogenetically up-domed, and causes distension beneath the geosyncline which, therefore, must subside. Thus, the slope of the land is increased, and the erosion is continuously activated. The stretching of the geosynclinal crust causes volcanism, giving basalts and ultrabasic rocks which are intercalated among the sediments. Extensive masses of sediments are deposited in the continentward part of the geosyncline, accelerating further subsidence (see fig. 4).

In the oceanward part of the geosyncline, sedimentation dwindles and does not completely compensate the subsidence, so that a sort of deep-sea trough is formed. In a more advanced stage, the base of the sinking portion reaches the ultimate level of the base of the crust beneath the continent, and geoisothermes become parallel to the geoidal level, while they become more inclined on the oceanward side. Consequently, the zone of impulsion shifts away from the continent. Thus, the impulsion itself is intensified and the action of the current is amplified and concentrated beneath the oceanward part of the geosyncline causing, there, distension of the crust and a powerful submarine volcanism, along the resulting abyssal fissures. That means degassation and cooling of the magma and, hence, increase of its density. The current gets deviated towards the depth, and the subsidence of the central part of the geosyncline is accelerated. Under these conditions, the geosyncline reaches rapidly its maturity and thus ends the primary stage of the orogenic cycle, to start then its secondary stage, i. e. the stage of tectogenesis and engulfment of the crust.

The Mechanical Behaviour of the Earth-crust

Before treating the structural deformation of the earth-crust, some remarks have to be made on the mechanical behaviour of the rocks

within the crust. In all deeply eroded mountain ranges, the rocks show signs of intense deformation : folding, schistosity, fluidal structures etc. As rocks are crystalline solid bodies, one is inclined to explain such deformations by plasticity (e. g. J. Goguel), i. e. an irreversible deformation that occurs if the deforming stresses are greater than the limit of elastic behaviour. Microscopical study of such metamorphosed rocks shows, however, that deformation is always accompanied by lamination and recrystallization. Both these processes have nothing to do with plasticity. They are very slow processes starting at the slightest long lasting stress, even under relatively low bulk pressure. Recrystallization is very much facilitated by water, the presence of which is proved by the frequent hydroxile bearing minerals in metamorphic and granitised rocks.

The very important time-factor, completely neglected in the theory of plasticity, must be taken into consideration. The behaviour of rock masses within the crust can therefore be compared with viscosity, but not with plasticity. This fact is another example which shows how dangerous it is to extrapolate lab experience to the large scale events of geology, where time and slow physico-chemical processes play the most important part. To conclude we may say, that, much deeper than the superficial parts of the crust rock masses would behave very much like an extremely viscous liquid, and that—at least as a first approximation—the relation of Maxwell is valid not only for the substratum, but also for the deeper crust.

Tectogenesis and the Engulfment of the Crust

Right from the beginning, the accelerated movement of the subcrustal current is transmitted to the crust by internal friction. In the mature geosyncline, the continentward part of the crust as weel as the overlying young sediments undergo compression and are pulled obliquely downwards towards the continent. In the deeper parts of the crust, rock-flowage takes place, while at higher levels, shearing stresses laminate the rocks (see fig. 4).

If the stresses becomes bigger than the ultimate shear strength, big scale shearing occurs along single planes. The resulting features are

the well known nappes. A. Amstutz, who has carefully studied some regions in the Penninic Alps, has shown that the formation of nappes starts with a shearing fracture, along which the lower part is pulled down obliquely under the upper part. He introduced the term « subduction » to replace the old misleading term « underthrust », because there is no thrusting. It results also from dynamics that the term subduction describes the phenomenon correctly, since gravity aids this mechanism, while it is opposed to that called overthrust. Furthermore, subduction explains fully the observed deformations of the rocks, while large scale underthrust or overthrust are incompatible with the mechanical behaviour of the material.

As the subcrustal current is directed towards the continent, then the subduction due to its action must also have the same direction. This is really the case in all mountain ranges, at least with regard to the earliest big scale deformations [1].

Subductions pull sialic masses into the magma-zone, where they form the so called « sialic root », as proved by seismology and gravimetry. The engulfment of relatively cool sial into the hotter magma-zone is accompanied by a considerable down-warping of the geoisothermes. It produces, in the continentward part of the geosyncline, a horizontal thermal gradient directed towards the sialic root, which may often be strong enough to create a powerful convection current. This secondary current has an opposite direction to that of the primary current. Both currents meet obliquely beneath the sialic root and cause a still greater engulfment of the crust. Sometimes, the secondary current is strong

[1] Only the Alps seemed to make an exception according to the cinematic picture of E. Argand and R. Staub. But, the discovery, made by A. Amstutz, that the St. Bernhard-nappe is in reality directed towards the Mediterranean and due to the subduction of the autochtonous Mt. Rosa beneath St. Bernhard, and that this is the first nappe formed in the Alps, is in full agreement with our theory. The vergence of the St. Bernhard-nappe towards the Mediterranean, i. e. exactly opposite to that supposed by Argand and Staub, was found to be true also in the French Alps (personal communication by M. Ellenberger). More details of greatest interest are exposed in the papers of A. Amstutz in *Archives Sc. Genève,* 1947-1955, and in C. R. Académie Science, Paris, 1952-1955.

enough to produce subductions in a direction opposite that of the first one [1].

The occurrence of reverse subductions does not mean that the primary current is acting no longer. On the contrary, its continuous activity is proved by the subsequent deformation of the shearing planes of the secondary subductions, by the so called « renversement des racines ». According to our theory, shearing subductions will happen if the stresses overcome the ultimate shear strength within the time of relaxation. This is possible only if the current is strongly accelerated in a limited but not too large a zone, i. e. if the geoisothermes are steeply inclined. They are so on both sides of the sialic root, and it depends only on which side the geothermal slope is steeper to decide in which direction the shearing subduction will take place. In any way, the primary current axists always, before, during, and after the orogenic cycle, but its power varies considerably in time and in space.

Orogenesis proper

The formation of the sialic root disturbs the hydrostatic and isostatic equilibria. Consequently, the engulfment of light sialic material reaches a limit that is characterized by the dynamic equilibrium between the down-pulling action of the currents and the opposite forces, set up by the isostatic disequilibrium. Here again, the dynamic equilibrium could last for ever, if independant forces would not disturb it in favour of the isostatic uplift (see fig. 4).

The relatively cool sialic masses forming the root are surrounded by hot subcrustal magma. Their thermal conductivity being very low, they are heated up very slowly. Rising temperature amplify the metamorphic processes which, at first in the deepest zones of the sialic root, produce partial melting of the sialic rocks with the formation of an intergranular supercritical solution of pegmatitic character (Sederholm's « ichor »). Migrating upwards this ichor causes allochemical

[1] Especially in the Alps, such reversed subductions are frequent. Some of them cut the shearing plane of the first one, as has been shown by A. Amstutz (*loc. cit*).

metamorphism : gneisses and migmatites are formed, then granitisation leads to a general homogeneisation. Beneath the zone of granitisation, the temperature rises (say over 600° C), and causes further remelting of the already granitized rocks and the formation of anatectic magma of rhyolitic (granitic) composition.

In the writer's opinion, the lower parts of the sialic root, from which the ichor has migrated, gain more and more a noritic composition. This « degranitized material» may be remelted at its turn, producing a bandaitic magma (i. e. an andesitic to dacitic magma, poor in alkalies, but relatively rich in aluminium). At the same time, the simatic undercrust is melted too and becomes subcrustal magma.

All these metamorphic and ultrametamorphic processes are reactions by which the matter adapts itself to the changing conditions of temperature and pressure which are disturbing the physico-chemical equilibria.

Metamorphism of the sediments in the higher levels causes an increase of density, while on the contrary gneissification, granitisation and anatexis causes it to decrease. Thus, the light masses formed in depth increase the negative gravity anomalies and the forces that tend to re-establish isostasy. The dynamic equilibrium, mentioned above, is thus upset, and the isostatic uplift of the already folded mountain range starts. Owing to the heterogeneity of the material, differential ascending movements set in. Especially the more mobile anatectic magmas intrude upwards and form diapiric plutons of granites, granodiorites, diorites etc.

The uplift is accompanied by secondary tectogenesis, characterized by the formation of flexures, faults, gravity nappes (the « nappes d'écoulement» of Lugeon, Gagnebin, Gignoux, Schneegans). Especially in later phases, faulting and the formation of tensile fissures predominate, creating favourable conditions for an intense orogenic volcanism of very explosive acid anatectic and hybrid magmas (e. g. Japan, Indonesia, Kamtshatka, Andes etc.).

Though the orogenic uplift is accelerated in its first phase, taken as a whole, it is an asymptotic process that ends with the peneplanation of the mountain range, and with the re-establishment of all geological equilibria. Thus, the orogenic cycle leads to a cratonisation of at least

a part of the ancient geosyncline, i. e. to a growth of the continental shield.

OVERLAPPING STAGES AND COMPLICATIONS

The scheme of the three stages of an orogenic cycle, i. e. the subdivision in to a geosynclinal, a tectogenetic, and an orogenetic stage as deduced above, generally holds only for a limited part of an orogenic belt. But a detailed study of a great mountain range reveals a chronological overlapping of these stages. While one sector of the belt has entered already into the stage of orogenetic uplift, another one may be in the stage of tectogenesis and engulfment, or even in the geosynclinal stage. Such differences depend upon local conditions during the preparatory geosynclinal stage. If e. g. the sial fades out rapidly, strong currents arise, and if, at the same time, the topography favours bulky sedimentation, the geosyncline will mature rapidly. Where the conditions are less favourable, the evolution of the geosyncline will be slow. Also the intensity of the following tectonical events may vary according to local conditions.

If one region of an orogenic belt evolves quicker than the neighbouring one, longitudinal slopes will result which may produce transverse structures of great importance. On the other hand, also in one and the same sector, the sialic root may be dragged by the current, causing a displacement of the loci of subduction. As a result of such events, the tectogenetic stage appears subdivided in to a series of tectonic phases. But whatever may be the complications and interferences, the principles of our scheme remain the same, and the orogenic cycle is still revealed as a series of reactions against upset geological equilibria.

Migration of Orogenesis

For the sake of volume-compensation, the uplift must be accompanied by a neighbouring subsidence. In fact, the subcrustal magma, sucked in by the uplift, is withdrawn from the adjacent regions. Fore deeps will be formed towards the continent, as well as towards the ocean. In the continental fore-deep, sediments are deposited (flysch and,

molasse), while the oceanic fore-deep will evolve toward a marginal deep-sea trough.

After the accomplishment of the orogenic cycle, this fore-deep will be transformed into a new geosyncline, as soon as the peneplanation of the old mountain range permits strong sedimentation. Already during the third stage of a cycle, the embrionic geosyncline of the next cycle is born. Successive cycles are, thus, linked together causally. Only the very long duration of the preparatory geosynclinal stage gives us the impression that mountain building is a paroxismal event after a long period of quietness. In reality, orogenic cycles constitute an uninterrupted chain of causes and effects, of disturbances and re-establishments of geological equilibria.

Relations between Orogenesis and Epirogenesis

It has already been said that, during the geosynclinal stage, the passive anterior branch of the subcrustal current is pushed under the continent, and that the resulting compression causes an updoming of the continent, an epirogenetic uplift of its inner parts. At the same time, the marginal parts of the continent are slightly involved in the geosynclinal subsidence, so that a more or less marked transgression of the sea takes place.

With the maturation of the geosyncline, the zone of impulsion migrates towards the ocean, and the uplifted parts of the continent grow larger, causing a certain regression of the sea. As soon as a sialic root is formed, the effects, of the primary current do not concern the continent any more, while the secondary opposite currents come into action and withdraw magma from beneath the continent. Consequently, the continental up-doming flattens. As the secondary currents are more localized, the drainage of magma is somewhat irregular and causes, besides the general negative epirogenetic movement, the subsidence of more circumscribed continental basins. Furthermore, the secondary currents produce stretching of the continental fore-land. Abyssal fissures and paraphoric faults with horizontal throw originate and permit the subcrustal magma to rise to the surface causing the continental fore-land volcanism.

This very schematical review of the relations between orogenesis and epirogenesis shows that the latter is a secondary effect to the former. Only orogenic belts are tectonically active, and all epirogenetic movements are only reflexes of the tectonically passive cratons to the events in the orogenic belts.

In order to avoid too rigid a scheme, some remarks have to be added. While the intensity of the currents depends essentially upon the degree of the wedging out of the sialic masses, their direction is determined by the geographical distribution of sial. This distribution determines the flow pattern of the currents, which may converge or diverge and vary in their intensity, causing all sorts of interferences, deviations, whirls etc. The overlying crust will be affected by more local uplifts and subsidences, by tensile fissures and shear faults with horizontal throws, whereby ancient structural patterns will be rejuvenated. Notwithstanding all these possible complications, the epirogenetic movements, taken as a whole, correspond to the scheme that has been outlined above.

Pacific and Atlantic Coast Types

In comparing figures 1 and 2, we note the fundamental difference of constitution and temperature distribution in the marginal parts of the sialic shields towards the Pacific Ocean and the Atlantic Ocean. The great horizontal temperature gradient beneath the Pacific margins causes powerful subcrustal convection currents which originate deep-sea throughs, geosynclines and orogenic cycles. On the contrary, beneath the Atlantic margins, the horizontal temperature gradients are smaller. Also here they produce subcrustal currents, but these are too weak to cause mountain building. However, the great number of submerged river beds, ancient shore lines and shelf edges on both sides of the Atlantic Ocean denote a subsidence, similar to that of a geosyncline. The difference between the two coast types is a quantitative one with regard to the intensity of the subcrustal currents, and is intrinsically due to the difference of the constitution of the earth crust.

Spreading Continents and Rift Valleys

B. Gutenberg has shown that sialic shields must have a tendency to spread over the surrounding simatic crust, in order to adjust the hydrostatic equilibrium. The forces set up by this tendency are, however, much too small to explain mountain building. Furthermore, they originate and act only at the margins of the shields and have hardly any effect on their bulk.

Things look different, if we take into consideration the updoming of the continents, due to convergent currents beneath them. H. Cloos has demonstrated that such an up-doming produces a far more effective spreading of the continental shields. In fact, the sialic masses undergo a centrifugal pull on the slopes of the dome, while the central parts, on the dome culmination, are stretched. There, the distension causes the formation of grabens and rift valleys with abyssal fissures and faults and concomitant volcanism of subcrustal origin.

The distention of the crust, accompanied by strong magmatic activity, causes a rising of the geoisothermes beneath the rift valleys. Horizontal temperature gradients are found and lead to the formation of a system of divergent subcrustal currents. Their effects are a further widening of the rift valley and an uplift of the adjacent parts of the continent, due to subcrustal compression.

Intercontinental Seas and the Drift of Continents

The larger a rift valley grows, the greater will become the activity of the two opposite diverging currents. The stretched bottom of the rift valley subsides more and more, partly because of the thinning out of the sialic layer, partly because of the suction of the currents. When its bottom sinks below sea level, an elongated intercontinental sea originates which is bordered by horst-like parts of the continent, as e. g. the Red Sea. As the diverging currents continue their action, the intercontinental sea will slowly grow larger.

The writer is convinced that the Atlantic Ocean originated in the manner just described. The continuous slow subsidence of Atlantic coasts, the Mid-Atlantic, Ridge, the Atlantic volcanism, as well as the praetertiary terrestrial connections suggested by palaeontological facts, find a logical explanation in assuming this origin. The strongest argument in favour of it, is the alkaline nature of the Atlantic volcanoes (i. e. basalt-trachyte and tephrite-phonolite series). If the Atlantic Ridge were a rising mountain range (as suggested by some geologists), the orogenic volcanism should produce lavas of the calc-alkaline series (i. e. andesite-dacite-rhyolite series), as they do all the world over without any exception [1]. Another proof is given by the constitution of the sub-atlantic crust that induced Gutenberg to consider it as a spread continent.

Seen in this light, Wegener's drift of the continents is only a geographical phenomenon, in the geological sense there is only a continental spreading, acccompanied by partial submergence.

Relative Displacement of the Sialic Roots

It has been already mentioned that the subcrustal currents can shift the sialic roots, and that such minor displacements lead to uplift or subsidence of certain zones within the orogenic belt. It seems, however, that major displacements of sialic roots can be caused by tidal and centrifugal forces, set up by the rotation of the earth. A. Wegener thought these forces to cause a « Westdrift» and a « Polflucht» of the « rigid» continents, floating on the « mobile» sima. Nowadays, we know for sure that continents are not rigid, but that they behave like extremely viscous masses. Tidal forces act therefore not upon an imaginary center of gravity, but separately on each particle of the crust. In consequence, the most elevated parts of the crust endure a stronger pull than the lower ones. This causes a deformation of the crust, due to a « differential» west-drift» that dies out asymptotically towards the depth. The higher parts of the crust flow very slowly in a western direction over the lower ones. Seen from the earth surface, this appears like an extremely slow subcrustal current directed towards east, the effect of which is superimposed to the effects of the more localized,

[1] A. Rittmann, *Bemerkungen zur Atlantis-Tagung,* Geol. Rundschau 1939.

but much more powerful, subcrustal convection currents that originate in orogenic belts.

The striking difference between the coastal ranges (Cordilleras) of western America and the Island Arcs of eastern Asia can be explained by such a differential west-drift. In America, the continent overrides the sialic roots of the Cordilleras which, therefore, are welded to the continent. In Asia, the continent withdraws from the sialic roots, leaving behind it a stretched and submerged region (e. g. the Japanese Sea), bordered by an Island Arc above the sialic root.

It is evident, that the displacement of sialic roots in respect to the surface must be strongest, where the differential west-drift and the subcrustal convection currents act in the same direction, as it is the case in western America, and to a certain extent also in Italy [1].

In many cases, similar displacements of sialic masses in the depth can explain the distribution of the very explosive and powerful post-orogenic volcanism (subsequent volcanism of Stille). During the orogenic stage, the deeper parts of the root is melted and mobilized. A displacement of the acid anatectic magmas can be compared with a lateral intrusion beneath the continent, causing uplift, distension and explosive volcanism. Acid fissure eruptions which cover wide areas with welded rhyolithic tuffs («ignimbrites») as e. g. in New Zealand, in the Yellowstone Park etc. are typical of this kind of volcanism. Ancient products of acid subsequent volcanism related to the Hercynian orogenic cycle, are widespread in Europe, and similar formations of very old age are to be found in the Eastern Desert of Egypt in great amounts.

Furthermore, the problem of rejuvenation of sial (Umbgrove) could find its explanation by the displacement of sialic roots in the form of

[1] Recent researches, carried out by A. Merla and C. Sommaruga and collaborators in Toscany, lead the writer to the conclusion that, also there, one has to deal with a combined action of differential west-drift and a strong primary convection current. In fact, the great subsidence of the tertiary mountain range of the Hesperidian Alps (now submerged by the Thyrrenian Sea), and the uplift of the Toscan Appenine, which is accompanied by acid intrusions and volcanism of the Catena Metallifera, can be explained by the displacement of the Hesperidian sialic root towards the east.

lateral intrusions of anatectic magmas which increase the thickness of the continental sialic layers, thus, compensating, the loss of sial by erosion at the surface.

Summary

Since 1941 the fundamental outlines of a theory of mountain building and volcanism has been developped by the writer on the base of thermodynamic principles. In the present paper a summary of it is given, and some results of more recent researches are added.

The origin and the mechanism of subcrustal convection currents and their effects are discussed. The consequent application of the principle that geological events are reactions that tend to re-establish undisturbed equilibria, permits a logical explanation of a great number of phenomena, such as the origin and nature of deep-sea troughs and geosynclines, the mechanism of mountain building, the relation of orogenesis and epirogenesis, the difference between Atlantic and Pacific coast types and that between Cordilleras and Island Arcs, the origin of rift valleys and of intercontinental seas etc.

THE PRINCIPAL INLETS OF CAIRO

BY

DAWLAT A. SADEK

In Cairo, the Capital of Egypt, Nature and man have combined in creating an area distinct from its neighbours and from other areas, and exhibiting an essential unity of its own. Nature laid down the ground plan on which man superimposed an intricate pattern of surface features. Over the years, as he selected from the opportunities afforded by the area and turned them to this own advantage, he transformed the natural landscape into a cultural one. The individuality of the city is thus based on normal human activities guided by the physical environment, which factors combined have enabled a single unmistakable centre to rise on the Nile banks.

Cairo occupies the northern end of a basin, extending from Old Cairo in the north, to Turah station in the south. On the west this basin is bounded by the Nile, while its eastern extremity is marked by the 30 m. contour line, which also forms the boundary between the cultivable lowland and the dry desert plateaux. To the east of Cairo there are the Moqattam Hills, which form a spur thrust westward from the main plateau right towards the eastern gates of Cairo. To the south lie the Hills of Turah rising very sharply from the valley edge, and attaining, in certain places, some 300 m. in height.

The extent to which Cairo could expand is therefore seen to be limited. Again, the inlets linking Egypt have been very much dictated, in past and present, by these same physical characteristics. The inlets are practically the natural lines of communication, except for certain exceptions which we shall discuss later.

The inlets to Cairo have accordingly changed but little ever since the birth and the vast inlargement of human activities led to the growth of a group of arteries linking the whole of Egypt (Fig. 1).

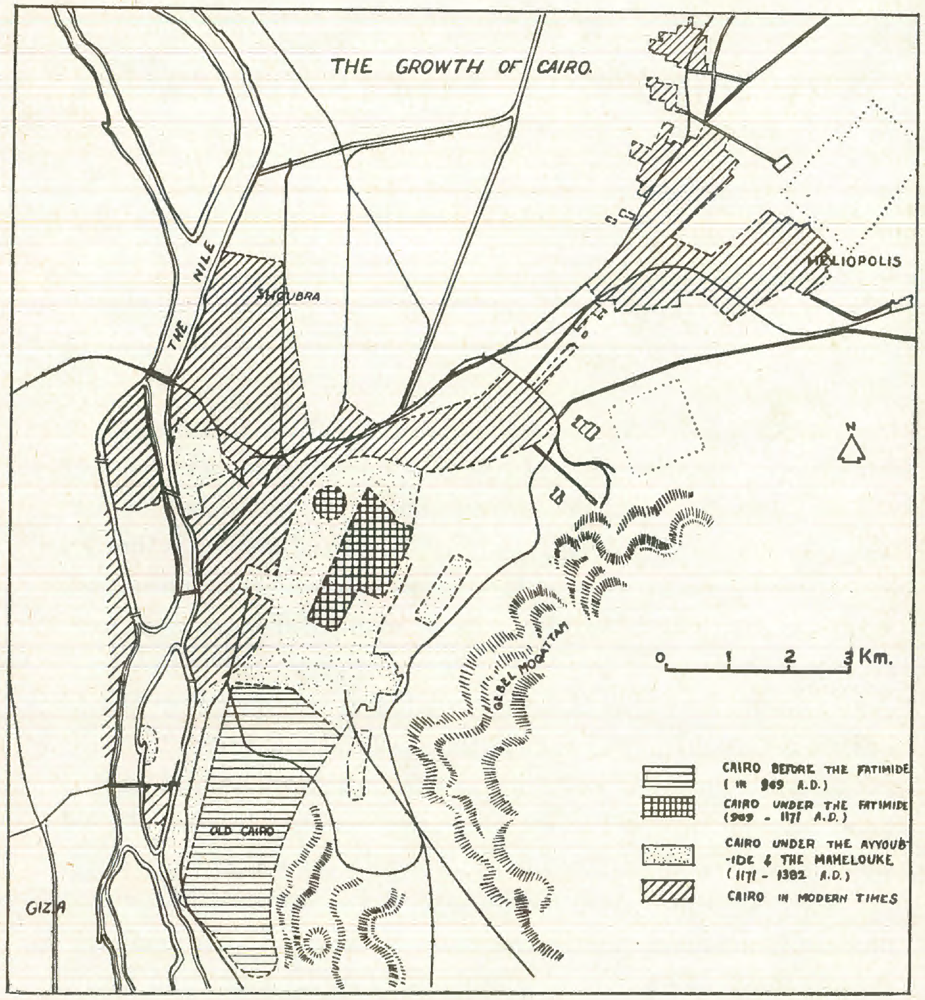


Fig. 1

Cairo at present comprises the northern part of the valley, being part of a long corridor, 500 miles in length (the total distance between Cairo and Aswan, is 554 miles). The first main artery is thus the important routeway between Upper Egypt and the South of Cairo.

It is noticeable that all along the course of the Nile from Aswan to Cairo, the river shows a marked tendency to occupy the eastern side of the valley. In some places the stream almost washes the feet of the eastern-bounding cliffs. Consequently the cultivable lands towards the west of the river are much wider than those on the east. This is the reason why the main southern inlet to Cairo reaches it from Giza on the western bank of the Nile. The main entrance for the flow of traffic from Upper Egypt, at the moment runs parallel to the Cairo-Upper Egypt railway-line, and reaches as far north as the entrance to the Pyramids road near the subway. This road is not at all suited to a free flow of traffic which comes from Upper Egypt, and has as its destination the different sections of the city.

North of Cairo the aspect of the country changed abruptly. The valley spreads out in a fan-like Delta, and the second main artery comprises the links between Cairo and the Delta. All the roads leading from the Delta to Cairo converge into a single opening along Shoubra bridge.

In this way, Cairo, the bridge-point between Upper Egypt and the Delta becomes the natural focus of Egypt. The bridge between the Delta and the Valley of the Nile, not only gathers the radial routes of the region but also forms the junction between the main route from North to South and the shortest route from the East to the West (the canal zone to Alexandria).

These outstanding features have been apparent for a long time but to-day they are brought out, even more clearly by the system of roads, which has greatly matured owing to the economic and political revolutions of the last few years.

As above-mentioned, the North road reaches the centre of Cairo through a narrow and congested road, « Shoubra Street ». This natural opening served its role fairly efficiently until the recent great growth of Cairo. Now it is incapable, of coping with all its through traffic. Shoubra Street is the main shopping centre, the back bone of the Shoubra and Rod-el-Farag districts, both of which are very highly populated areas containing nearly 320,900 persons. Having all the through traffic in the midst of such a very congested area, is against the basic principles of modern city planning.

A third entrance which serves its function better than the first two, is the Cairo-Alexandria desert road, but even this artery has its defects for to reach it from the centre of the town, the driver has to travel a comparatively long distance southwards to the Pyramids area before he gets to the road. This naturally involves a waste of time, money, and fuel.

The Cairo-Suez road, the fourth entrance, is not a natural part of the road pattern of Cairo. It was the result of the British military occupation of the Canal zone.

The road to the Southern Suburbs of Cairo, to Maadi and to Helwan is not at the moment a proper road inasmuch as its condition is concerned. Both residential and industrial factors have led to the present construction of Cairo, but the newer factors are exclusively industrial. Topographically, modern growth has welded Cairo and Helwan into one geographical unit. The agricultural lands on both sides of the existing road are being gradually annexed for building purpose. Furthermore the electrification of the Cairo-Helwan line will encourage city people to seek better residences outside Cairo.

Thus clearly do we see how road, rail and river together with the industrialisation of the suburbs of Cairo, have led to its importance as a major commercial and industrial centre of the country. But the main inlets to Cairo do not meet its functional status as the first city, and the capital of Egypt. It is an old and narrow bridge accross the Ismailia canal which connects the different parts of the Delta with Cairo, a bridge which is, or soon will be, little less than useless in performing its duty. At present, to aggravate the situation, the bridge is let up twice daily to allow the flow of traffic from the canal to the river. In fact there should be more than one inlet. The building of a road along the eastern bank of the Nile parallel to Shoubra has two aims : to provide the flow of traffic to and from the industrialised area of Shoubra El-Khima with a reasonably high speed and to serve as an outlet to the very highly overcrowded residential districts, especially Rod-El-Farag and Boulac.

This road (the Corniche) leading from old Cairo and Shoubra El Khima to Helwan has actually been completed, and has a total length

of 35 km. It will, it is hoped, relieve Shoubra road to a very great extent, and will itself become the back-bone of the area. It expect, moreover, that this road will carry the traffic from the central provinces, and some of western ones. A good deal of this traffic has as its object the central areas of Cairo, and it would be a good idea were another road built alongside the Cairo-Alexandria railway-line from Shoubra Palace, north of the Ismailia canal, to the Central Railway station. This will facilitate a direct movement from the Delta to the centre of the city. It will also act as a barrier between the railway lines and the houses.

Mostorod bridge in the North connects the eastern parts of the Delta with Cairo. From this area a person can travel directly to Cobba area, to Heliopolis, and to the North-East of Cairo. There should be a road joining Mostorod bridge with the newly constructed Ghamra road, the extension of the northern part of Khalig street to the Ismailia canal.

The southern outlet to Upper Egypt would be relieved to a considerable extent if the road from Giza bridge southwards to Bandar El-Giza along the Nile were widened and extended as far as Sakiet Mekki, where it would join the existing Cairo-Upper Egypt road. Were this done, the traffic from the South would not need to enter the Pyramids road at the Ahram Subway and then cut through Giza and the tram lines. Furthermore this new road would directly connect the southern outlet with the Corniche at Abbas bridge, from there to Embaba, and from Embaba to the newly established province, Mudiriat el Tahreer.

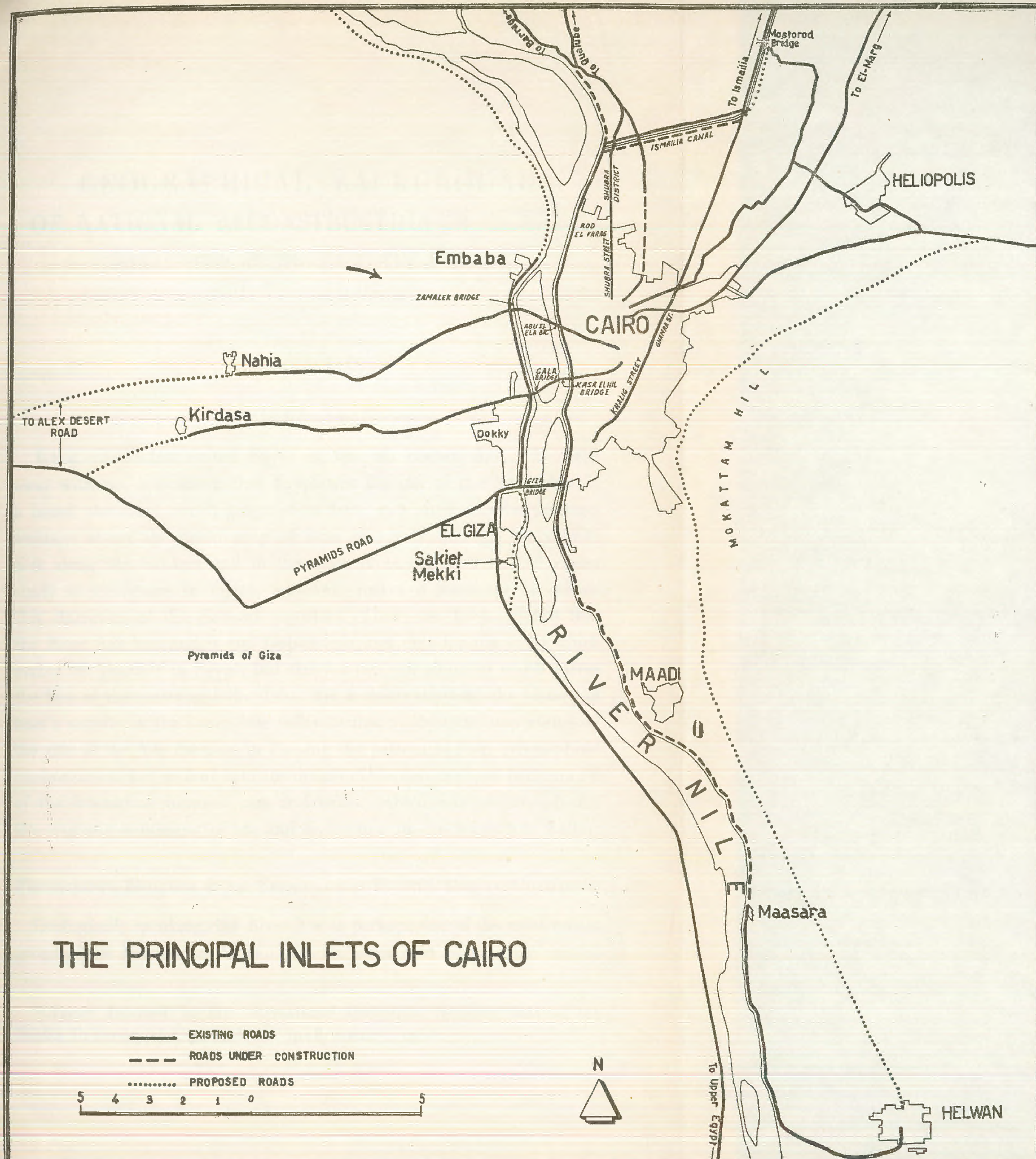
The Alexandria desert road could have two direct connections with the city :

1. Through Awkaf city immediately after Zamalek bridge (where there is a road 100 m. wide).
2. Through Dokky along Tahreer street after Gala Bridge.

These two roads are connected directly to the city by Zamalek, Abou El-Ela, Gala and Kasr-El-Nile bridges.

The Suez road at present has its origin in Heliopolis, via the Central Railway station. Therefore to reach Heliopolis from Suez one is forced to use the main and congested highway, leading from the station to Heliopolis.

The establishment of military industries in Maasara and Helwan, together with the fact that the Canal zone is fast becoming an Egyptian Military Base invites the planner to think of a road running at the foot of the Moqattam hill from Helwan to the Red mountain, and then along the boundaries of Abbassia barracks to the Suez road. This road would connect the military industries to the main centre of town. From the town planning point of view it is a most desirable road one connecting Helwan, Cairo and Suez. At convenient points there could be branch-offs into the city proper.


THE PRINCIPAL INLETS OF CAIRO
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SHUBRA STREET
Embaba
ZAMALEK BRIDGE
CAIRO
ABU EL ELA BR.
EMAD ST.
Nahia
GALA BRIDGE
KASR EL NIL BRIDGE
KHALIG STREET
TO ALEX DESERT ROAD
Kirdasa
Dokky
MOKATTAM HILL
GIZA BRIDGE
EL GIZA
PYRAMIDS ROAD
Sakiet Mekki
Pyramids of Giza
RIVER NILE
MAADI
Maasara
To Upper Egypt
HELWAN

GEOGRAPHICAL BACKGROUND
OF NATIONAL RECONSTRUCTION IN EGYPT :
REFLECTIONS ON THE PAST, THE PRESENT AND THE FUTURE [1]

BY

S. HUZAYYIN

INTRODUCTORY

When Herodotus visited Egypt in the vth century B.-C., he went away with the impression that Egypt was the gift of the Nile. This is a broad statement which geographers have ever since adopted in their writings about the green strip of land that cuts through the desert-belt along the borders and in the delta of this great river. A closer study of conditions in Egypt, however, makes it necessary to qualify this statement of the classical traveller. There can be no doubt that the River Nile was and is still responsible, not only for the water which makes life possible in Egypt, but also for the rich alluvium which covers the bed of the valley and the delta. Yet a closer study of the history of man's activity in the lower Nile valley brings to light the importance of the rôle of the Nile dwellers in shaping the pattern of their geographical environment. Let us look into the details of the geographical background of the interaction between *man* and *milieu,* which was responsible for the rise and continuity of life and civilization in the lower Nile Valley.

PHYSIOGRAPHIC EVOLUTION OF THE CRADLE-LAND OF EGYPTIAN LIFE AND CIVILIZATION

Geologically speaking, the River Nile is perhaps one of the most recent geographical features in Africa. Yet its lower part became the seat of

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one of the earliest civilizations known on earth. This civilization became also characterized by singular continuity all through the ages. Ever since man knew how to cultivate seeds in the lower Nile valley towards the end of the sixth millenium B.-C. the good land of Egypt was cultivated regularly every year down to the present day. In addition to this continuity culture was regularly renewed through new additions and renovations which we shall try to review a little later. This progressive continuity of life and civilization in Egypt could not have been the result of sheer chance. It was built upon a number of fundamental phenomena, both natural and human. In its present form and dimensions the River Nile does not go beyond the Middle Pleistocene. Before that there were three distinct river-systems—in the equatorial plateau, in Abyssinia, and in Nubia and Egypt respectively. The latter system depended entirely on the local rainfall, during the Pluvial Period—the equivalent of the Ice Age in Europe. During this Pluvial Period the northern system of the River Nile which started in the Miocene, gradually took its present shape. The bottom and sides of the valley were filled or covered with thick layers of gravel and sands brought from the eastern deserts of Egypt through what are now dry wadis. It is both interesting and significant that before the Pluvial Period had gradually approached its closing stages, important earth movements and hydrographic changes were taking place in the upper reaches of the Nile. As a result, the waters of both the equatorial plateau and Abyssinia reached the Nubian-Egyptian valley. Abyssinia was the more important source, and from it came the seasonal inundations which brought the valuable mud. This rich alluvium, descending from the disintegrating volcanic surface of Abyssinia, was spread in Egypt over the earlier beds of sand and gravel. The diminishing rainfall in Egypt made it possible for the mud to settle down, as there were no violent local torrents to wash it away into the Mediterranean. Thus the change of climate in Egypt towards the end of the Pluvial Period made it possible for the soil of the Nile to settle down, instead of being eroded away. At the same time the fact that the deposition of sands and gravel preceded that of Abyssinian mud, made it possible for the waters of the flood to percolate into the subsoil and drain away towards the sea. Thus the surface of the new soil in

Egypt became largely free from swamps and marshes which would have otherwise formed over the alluvium if the porous subsoil layer did not exist. This was a very important feature of difference between Egypt and Iraq, where subsoil drainage was almost inexistant, and where the cultivated land could not maintain its fertility owing to the development of salts and marshes. We may see how the sequence of events led to the formation of the good land of Egypt, and made it possible for the lower Nile Valley to become one of the earliest, if not the first cradle-land for large-scale settlement and agricultural civilization.

Geographical Environment and the Rise of United Community in the Lower Nile Valley

But there were still other geographical features which contributed towards this end, and which made it possible for life to continue and develop along the borders of the Nile. We know that written history started in Egypt with the Ist Dynasty of the Pharaohs about 3200 B.-C. But before that there was a long phase during which Egyptian society was gradually taking shape. We call it the predynastic period, and it covers some 12 to 15 centuries. Egyptian society was gradually learning to live in unity along the borders of the Nile. The Valley became a big school in which groups of settlers were gradually learning the art of local government and of united community. This was an interesting phase of human adjustment to the geographical environment, and the lesson which those early ancestors learnt from nature was never forgotten. The mighty River Nile had taught those early societies the art of community life which still characterizes Egyptian rural society down to the present day. Let us recall that the seasonal flood of the River Nile was a source of common danger, because it meant irregular and often devastating inundation of all the land. To be able to settle in a village above the flood plain, it was necessary for those early settlers to build up a large artificial mound of earth in order to set up the houses on its crest. It was impossible for any small group or family to content itself with a small isolated mound on which to erect its habitation, for such a small mound would have been easily swept away by the flood. It was

thus essential for the early settlers to live in large village communities, where numbers of families had to cooperate and live together. The common danger of flood had also to be controlled through the erection of large and high banks all along the sides of the River bed. Neighbouring villages had to cooperate amongst themselves for the erection of these high banks as well as for guarding them with vigilance during the flood season. This meant not only the development of cooperative effort but also the organization of the work and the rise of a system of administration and regional government. This represented the earliest stages of regional unity and local government along the banks of the Nile, long before they were known in other parts of the world.

But there was another incentive for unity and for the development of community life in early Egypt. We know that since very early times agriculture in Egypt was not of that primitive type which depended on rainfall. It was necessary in order to cultivate the land of Egypt to regulate the flow of water from the River Nile for irrigation. This meant the control of the waters of the River and the division of the plain and delta into what we call irrigation basins. It was necessary to built up large banks around each of those basins, into which the water could bring the silt. It was also necessary to dig large canals to lead the water from the River bed into the basins and out again after a certain amount of mud had settled down. The transformation of the land into basins and the digging of large irrigation systems was essential for the development and upkeep of the agricultural land of Egypt. This meant a great effort without which the River Nile would have flowed irregularly, changing its course and eroding the soil from one side to the other. In order to draw the benefit of regular irrigation from the Nile, a great and sustained effort had to be made by the early settlers in Egypt. Indeed the good land of Egypt, which became the cradle and seat of a highly developing agricultural life all through the ages, was the combined fruit of human work and a natural environment which was capable of being controlled. In other words this land was not the simple or easy gift of the River Nile as Herodotus tried to describe it. Organized work and unified effort were as essential as the liberal supply of water and silt from the Nile. But the development of basins and the digging of

canals were in themselves a great incentive for unity and for the development of early government and community life amongst those very early Egyptians. The same incentive continued to perform its rôle in Egyptian society down to the present day.

Thus we may well see how the environment of Egypt taught the Egyptians from very early times to live in an organized and united community. In other words, it was not by mere chance that the first really large-scale government was first known in Egypt. The unity had to be maintained through the ages because the common source of danger from the flood, and the common source of benefit from irrigation, represented a regular annual feature in the life of the Egyptians. The River Nile also worked as a regular highway for communication between Lower and Upper Egypt. It is interesting to note that the river flows from south to north—thus making it easy for the boats to descend downstream. At the same time the regular wind system is from north—thus inspiring the early Egyptians to use the sail which helps to drive boats upstream. In other words the fact that the Nile flowed northwards and that the wind blew in the opposite direction represented two geographical features which complemented each other. Had the Nile flowed in the direction of the Tigris and the Euphrates, unity in ancient as well as historical Egypt would have been as difficult as that of Iraq—a land in which a number of historic and separate civilizations developed in Sumer, Babylonia, Assyria and other basins and plains.

The keynote of Egyptian life throughout history is the true adjustment and response of men to the call of unity. This unity, which nature itself taught the Egyptian, was essential, not only for the maintenance of good government, but also for the good exploitation of the local resources of the good land of Egypt. It is interesting to note that periods during which this unity was maintained were characterized by great prosperity and development. On the other hand, periods of administrative disintegration were those of feudalism and decline in the life of the people of Egypt.

But the spirit of this natural unity was not only exemplified in the administrative system of a central government. It was also, and indeed is still clearly exemplified in the life of the Egyptian rural communities. The village of the Egyptian countryside is an exceptionally good example

of a community whose life is characterized by social cooperation and mutual help between its members. Features of social solidarity within the village group may be seen in the every day life of the Egyptian villagers. These features represent some of the sources of strength in the life of the Egyptian community groups. It is these sources of strength which led to the continuity in the life of Egypt, and made the Egyptian society fit for survival right through the long centuries of its almost uninterrupted history.

The Rôle of the Desert in Egyptian Life and History :

Let us now leave the Nile valley and pass on to the adjoining deserts which represented another geographical feature affecting the life and history of the Egyptian society. Unlike the deserts and steppe-lands bordering Iraq, most of the deserts of Egypt were particularly dry. They maintained very few bedouin groups, and represented no immediate source of danger for the settled life of the irrigated lands of Egypt. There were no large communities of moving tribes who could encroach upon the settled life of the villagers and change the social pattern of the country. On the contrary, the deserts of Egypt were so dry and so sparsely inhabited that they represented shields which protected the settled land of the valley, and helped it maintain its pattern of life. Let us contrast this with what happened on the plains of Iraq, where the settled land was often overrun by overwhelmingly large groups of bedouins who repeatedly destroyed life on the cultivated lands of the Tigris and Euphrates. It is true that from time to time Egypt received invasions from east or from west; but these invasions always came in small groups which were readily assimilated by the Egyptian population, especially on the wide plains of the Delta. Indeed the deserts of Egypt were like sieves through which were able to percolate only the adventurous and hardy elements coming from the steppe-lands of North Arabia, or from the Libyan coastlands of the Mediterranean. Thus the deserts of Egypt did not shut it off entirely from the neighbouring world, but rather regulated its space-relationships and made it possible only for small groups to get through. These infusions from across the

desert enriched Egypt with new adventurous elements who added to its blood heritage, but did not alter the racial pattern to any extent that would obliterate the Egyptian Nilotic pattern of the population. Similar infusions also came either from the heart of Africa and the Sudan along the River Nile, or from the opposite shores of the Mediterranean in south Europe. Egypt became a nodal point which attracted elements from all directions, but only selected groups could finally reach this desired land. The deserts bordering Egypt helped this country to maintain its personality by never allowing the floods of racial migrations to overwhelm its settled land. The Mediterranean in the north also played a somewhat similar rôle.

The Geographical Situation as a Factor in Egyptian History

But the story of interaction between man and environment in Egypt can never be complete without due reference to the geographical situation of this great cradle of human civilization. Within the whole of the Pharaonic period, space-relationships between Egypt and the outside world were limited to the neighbouring regions in Africa, Asia, and Europe. Most of the Pharaonic period was characterized by peaceful relationships. The Old Kingdom of Egypt, for example, enjoyed some 700 years of constructive peace—an interval which no great civilization ever seemed to have enjoyed. During that interval the Egyptians set the historic example of spending all their extra energy in building up great pyramids of stone, instead of dissipating that extra energy upon destructive war. Even during the New Kingdom, when the Egyptians began first to defend their borders, and then to build up an empire, they never extended their war relations beyond the heart of the Near East. Humanity did not know about war as a world-wide phenomenon until the late days of the Greeks under Alexander the Great. Pharaonic Egypt can claim to have established a great civilization in antiquity which was largely characterized by peaceful relationships, and never went beyond the stage of regional warfare. When Alexander the Great came, he was the first to take his troops from one political and cultural region to another, until he stirred up world opinion in what was really

World War I in history. His troops passed from Greece to Asia Minor, the Levant, Egypt and Libya, back to Western Asia, Iraq and Ancient Persia, and then to Turkistan and the borders of the ancient Chinese empire, before they went southwards to India, and then back to Persia and Iraq. Thus for the first time in human history a number of cultural zones came into direct clash with each other. A world empire was then born, though it was very short-lived. As a result of this world clash which covered the borders of three continents, the geographical situation of Egypt came to the fore-front. From that time onwards, it became an important and often determining factor in the life and history of Egypt and the Egyptians. During periods when Egypt was a prosperous land and maintained its unity and strength, its people knew how to utilize their geographical situation in linking up East and West, both in trade and in culture. During such phases the geographical situation of Egypt was a blessing to its people and a contributing factor in the development of peaceful relationships between East and West. During other phases, however, when outside elements tried to dominate the geographical situation of Egypt, this good corner-land was exploited by outsiders to build up world empires—such as what happened under the Romans in classical times, the Turks in medieval times, or the British in times of our own. Right through history, however, Egypt and the Egyptian people remained faithful to themselves and to the world as a whole. The spirit of Egypt based upon their faith in unity was reflected upon their attitude towards the unity of the world and the essential rôle of Egypt as the peaceful link between East and West. Thus, in spite of foreign domination during intervals since the war of Alexander the Great, Egypt never lost its own personality; and it continued to live its own life right through the ages. For Egypt, the main outcome of the appearance of the idea of world unity was that this corner-land became more and more conscious of its rôle as the focal point between the three great continents of the Old World.

Progressive Continuity of Egyptian Life and Culture

But let us elaborate this latter point in a little more detail. Egypt was a great and traditional cradle-land of human life and civilization.

Its culture was characterized both by its great antiquity and its almost uninterrupted continuity. In this respect Egypt differed from many other cradle-lands of civilization. Let us recall that the cultures of ancient Sumer and Assyria, or those of Ancient Greece and Rome all died away. On the other hand, the agricultural life of Egypt, together with its social and cultural pattern continued right through the ages. It is true there were ups and downs in Egyptian history, but the life and culture of the people of Egypt were never interrupted right to the present day. This is a sign of singular vitality and fitness for survival. It is important at this stage to make a correction of an often-made statement—namely that the peasant society of rural Egypt is a conservative one. The peasants of the villages and fields of Egypt have constantly renewed the pattern of their work and life from period to period through their long history. There has been a constant renewal of the plants cultivated in Egypt, as the Egyptians have most readily introduced new plants from time to time. Barley and wheat were known since Neolithic times, but clover seems to have been introduced only some 500 years ago. Flax was cultivated in Pharaonic times, but cotton was introduced on a large scale only in the early 19th century. African millet was known perhaps in late prehistoric times, but maize was introduced from America after its discovery, and cultivated extensively only less than 150 years ago. In recent times the Egyptian peasant has also taken to the cultivation of large numbers of new plants including fruit-trees introduced from South-East Asia, which added to the fruit wealth of grapes, figs and other trees of the Mediterranean. The Egyptian peasant also took to new methods and tools of cultivation which added to his technical skill from time to time. The hoe was known in prehistoric times, but the plough was first invented late in the Old Kingdom. The so-called shadoof was known since very early times and used for lifting water with buckets drawn by man power from canals, but the so-called sakkiah or waterwheel became known in Graeco-Roman times and was worked with animal power. About the same time the Archimedes screw became also known. In modern times the Egyptian peasants are becoming used to mechanical water-pumps which work side by side with the old methods. Walking through Egyptian fields one would also become

impressed with the presence of modern tractors being used together with the old and traditional ploughs. One would not be justified, therefore, in taking the presence of the old and traditional methods as signifying conservatism, while ignoring the fact that the existence of the new methods should signify a progressive spirit. What seems to be paradoxical about the Egyptian countryside is the coexistence of some of the old and the new methods. This, however, should be explained in the light of the fact that some of our old methods became so well adapted to our conditions that it would have been senseless and of no practical benefit to change them. The Egyptian peasant preferred to add the new progressive methods to some of the old ones which proved fit to survive. This led to a vast and progressive enrichment of his material heritage. We may mention, for exemple, that the modern tractor would be very useful for use on large fields, but could not possibly replace the old plough on small strips of land, or even for special types of ploughing the earth. That is why, our peasant finds it more useful and more practical to combine the old with the new. This is far from being conservative. The progressive spirit of the peasants of Egypt, which represents a most valuable asset for modern Egypt, is present also in the cultural aspect of their life. The Egyptians have always been ready to adopt new attitudes and new types of culture. Perhaps no people in history have suffered less from that inferiority complex vis-à-vis foreign cultures than the people of Egypt. It seems that the Egyptians, who were amongst the earliest contributors to the development of human culture and civilization, have always felt so self-confident that they feared no danger of having their cultural pattern obliterated by borrowing from the outside world. Since the earliest stages of their history, their cultural life and thought were based on the principle of give-and-take. Needless to add, this is the principle any people should follow if they were to become part and parcel of the cultural heritage of humanity as a whole. One of the main sources of strength in the life and culture of Egypt, both in the past and in the present, was the fact that it combined creation with adoption. In the Pharaonic phase Egypt gave freely many of its cultural traits to its hinterland in Africa. It also contributed immensely to the development of culture and civilization in ancient Phoenicia and

Greece. At the same time it received and adopted many of the cultural elements evolved in the Semitic world. Later on Egypt adopted the culture of Greece; and when this latter went on the down grade, Alexandria became the seat of Greek thought and philosophy. Egypt mothered the culture of Greece, nourished it and preserved it until it was later on handed to the Arabs, who passed it to the Western World. If it were not for Egypt, it would have been difficult for us to imagine how the survival of Greek heritage could have taken place. During the Alexandrian phase Egypt played the dual part of the creator and the fosterer of culture. When Christianity appeared, Egypt adopted one of its branches and became the seat of the well-established Coptic Church, which spread the faith as far as Abyssinia. Later on Islam appeared and found its way into Egypt. Egypt also readily adopted the new pattern of Arab culture, and Cairo—instead of Alexandria—became the new seat of adoption. Al-Azhar—the mosque and university—became the great world centre of Islamic learning, and played the traditional rôle of the school of Alexandria. Again the progressive spirit of Egypt was manifested in a magnificent way. Egypt became one of the great centres of Arab and Islamic civilization, and the Egyptians took readily to the new change, and played their part of creation and adoption in the field of the new culture. But this world rôle of Egypt did not end with the Arab and Islamic phase. In modern times Egypt is again performing the same rôle which it played in history as the link between East and West. Let us recall that Egypt was the first Eastern and Islamic country to get into direct contact with the West. The expedition of Napoleon at the close of the 18th century represented a blow which the West gave to the East, and a clash which led to the awakening of Egypt as a prelude to the awakening of the East. The Egyptian people were again very quick to respond to the shock of the blow, and to rise from the dormant phase of Turkish domination. The revival of Modern Egypt in the, 19th and 20th centuries was marked not only with the great development in agriculture and perennial irrigation, but also with a magnificent revival in the domain of education and culture. Egypt was the first Eastern and Islamic land to adopt Western technique and to introduce Western learning and thought. Unlike what happened in some other

Eastern and Islamic countries, modern Egypt was able to achieve a happy combination of the traditional and the new patterns of thought and culture. This was in line with that happened again and again throughout her long history. Egypt renovated her system of education; and inspite of foreign occupation she was able to build up modern universities and centres of learning. The westernization of her education, however, enriched and did not overwhelm or obliterate the originality of her national pattern. On the other land, this old as well as young country was able to assimilate Western culture and maintain her own Eastern pattern. At the same time Egypt became the gateway through which Western ideas penetrated and spread both southwards into the Sudan and eastwards into Western Asia. Again Cairo and Alexandria were destined to play their traditional rôle as centres of both creation and transmission of culture and thought.

Concluding Reflections on the Future :

Let us conclude these notes with some reflections on the future. We have already tried to put our finger on some of the fundamental sources of strength in the life and thought of the Egyptian society through the ages. The Egyptians represented a people who lived in a remarkably propitious environment. This environment was most suitable as a cradle-land for a settled and continuous civilization. The Nile was the father and giver of life in this arid land, but it needed great and sustained efforts on the part of its sons to put it under control and prevent it from being a devastating inundator. The same effort was necessary to draw the full benefits from the land and water of the Nile. The life and civilization of Egypt were therefore the result of the combination of a suitable environment with a vigilant and hard-working human community. This was true of the past. It certainly remains equally true of the present and the future. But the Egyptians in their history did not work or live entirely for themselves. The culture which they evolved and nourished became part of the human heritage as a whole. It was based on the principle of give-and-take. No spirit of egoism prevented the Egyptians from giving the fruit of their historic efforts to the world; and no complex of inferiority prevented them from borrowing freely

from the fruits of other peoples. The Egyptians therefore played their full part as a society which lived for itself as well as for the world. The keynote of their history was the peaceful exploitation of their geographical situation during periods when that situation was not dominated by aggressors from without. Being in the centre of the world, they adopted new cultures from the East and the West with which they enriched their own civilization as well as the heritage of humanity as a whole. It was most fortunate that the Egyptians were able to combine their pride in the cultural past with a progressive openmindedness which enabled them to renew their culture from time to time.

At the present day Egypt stands at the dawn of a new era of its long history. It was natural that this long history was characterized with phases of dormancy and others of revival and activity. Phases of dormant activity never meant death for Egyptian life and civilization, as they did in the case of other lands. From time to time, the latent vitality of the Egyptian people would stir up and flare in the form of a big movement of revival. This is what is happening in Egypt of today. This old as well as young country is witnessing new trends of revival in the economic, the social and the cultural spheres. Economic development is essential for the uplift of the standard of living through a fuller exploitation of natural resources. The social reform means the end of feudalism and the revival of the community spirit of traditional Egypt. In the field of culture Egypt of today is again trying to play her traditional rôle in human history. Not only is she striving to foster her own cultural revival, but also she is energetically helping towards a wider revival in the whole of the Arab world. Egypt of the present day and of the future fully realises her duty towards the neighbouring world. Perhaps it is a welcome sign that in this new revival the impulse to «give» is more dominant than the urge to «take». This is a reflection of the spirit of historic Egypt which built her glory in the past upon the principles of peace and generosity. It is gratifying to feel that this spirit of Egypt is being met with a ready response on the part of the whole of the Arab world in Asia and in Africa. We look foreward to see this enlarging spirit of mutual and peaceful cooperation in the field of culture and thought find its echo in wider and wider circles in more distant lands.

FOOD RESOURCES

AND

THE GROWTH OF POPULATION IN EGYPT [1]

BY

M. M. AL-SAYYAD

A preliminary study of food conditions in Egypt has been recently made by the Nutrition Department in the Ministry of Public Health. The results suggested that the nutritional level and the health of the people as a whole appeared to have much declined during the last few decades. The individual intakes of food were calculated on the assumption of the absolute parity in consumption among all categories of the Egyptians; the per capita intake being 347 kg, producing 2352 calories daily, which is below the required standard. And even this low standard is not maintained by all the people, specially among the peasants, who are the producers of the foodstuffs. Their calories intake is 20 % less than the average, although they shoulder the heaviest burden in the Egyptian production. It was proved that there was a deficit in the daily individual intake in Egypt of 12.5 % in cereals, 50 % in vegetables and fruits, 100 % in meat and milk, and 200 % in eggs and fish. They get sufficient intake of sugar and vegetable oils.

This under-nourishment is generally cited as one of the main causes of poverty in Egypt. Expansion of cultivated land, diversification of agricultural production, increasing efficiency of production, and so on, are urged as remedies for improving nutritional standards.

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1. Expansion of cultivated land.

The total area of the Republic of Egypt is some 200 million feddans. Only six million f. of this vast area are under cultivation, that is about 3 % of the whole area. This cultivated land is a narrow strip stretching along the River Nile, mainly on the Western bank; and in the North of Cairo it widens to form the Delta, which is flanked on both sides by deserts : the Libyan Desert on the west and the Arab Desert on the east. This cultivated land is as follows :

	Feddans	*Feddans*
1. Lower Egypt :		
Eastern Delta	1,410,000	
Western Delta	747,000	
Central Delta	1,516,000	
		3,673,700
2 Upper Egypt :		
Perennial irrigation	1,787,000	
Basin irrigation	763,000	
		2,550,000
Total		6,223,700

Unfortunately, there has been no balance between the expansion of this cultivated land and the growth of population during the last fifty years. The gap was getting wider and wider, and while the cultivated land was increasing very slowly, the growth of population continues at a very high rate. The cultivated land rose from 5.1 million feddans in 1897 to 6.2 million f. in 1947 this is about 20 %, while the increase of population was about 96 % during the same period. The total population of Egypt was 9.7 million in 1897 and 19,1 million in 1947.

Agriculture has been the fundamental basis of the National Economy of Egypt and it will continue to be so for a long time. About 2/3 of the National wealth is invested in the agricultural field, 7/10 of the population have a kind or other of relation with the land, approximately 3/5 of the annual income is drawn from agriculture. Yet a great part of the Nile water still goes in vain to the sea. We have constructed dams and barrages, made one of the best canal systems of the world, but

there is still a lot to do to control the waters of the life-sustaining river. Perennial irrigation has been successfully introduced to Egypt since the beginning of this century, but there is still some 700.000 feddans in Upper-Egypt under the old system of basin irrigation. In addition to that, still a vast area of cultivable land has not been used till now. It could be put under cultivation, had it got the necessary water.

To meet the problem, Egypt has adapted a short term policy and a long term one.

a) Short term policy :

This is based on the full exploitation of the present water resources, from the river and the drains, which chemical analysis proves that their water is suitable for irrigation. This will answer the purpose of reclaiming some 300.000 feddans in the Delta, half of which is privately owned.

b) Long term policy :

This is based on the construction of the New High Dam to the south of Aswan Dam. The new dam will permit storage at a level of 180 m. The level of storage in the Aswan Dam at present is only 121 m. The capacity of the new dam will be 130.000 million cubic metres as against 5.000 million c. m. which is the capacity of the Aswan Dam. This will increase the land under plough to the extent of two million feddans, including the transformation of the existing irrigation basins in Upper Egypt to the perennial system. The project will provide for the generation of electric energy at a cost estimated at 6 milliemes per kilowatt, and this will make it economical to pump up water to cultivate about four million feddans in the desert, where soil is suitable for cultivation.

It goes without saying that the Agrarian Reform Law which sets a maximum size of land ownerships will result in increasing the number of people who will benefit from any expansion of the cultivated area.

II. Diversification of agricultural production.

Since the beginning of the XIXth century, Egyptian economy has been dependent on one crop, that is cotton. The radical change in the

irrigation system was to provide enough water for this newly cultivated summer crop. The expansion of the area under cotton has not, in fact, effected the extent of winter and flood crops which are mainly cereals. It was, in effect, an addition to the total crop area of the country, and cereals continue to occupy about 46 % of the crop area. This high percentage is not a sound economic principle for the maximum exploitation of our lands. But as long as our production is still less than our consumption, we have to go on, till we find a source of cereals at reasonable prices in the neighbouring countries. Cereals for human consumption in Egypt consists of wheat, maize, millet, barley and rice. All the output is locally consumed, except a small portion of rice. We usually import some wheat from Europe and Australia.

In fact, there is no balance between the nutritive value of the average yield per feddan of the various crops and its total area. It is, therefore, very essential to redistribute the cultivable land among the different crops. Vegetables and fruits occupy no more than 4 % of the cultivated land, although they are highly calories producers. One feddan of Banana for instance produces 4,4 million calories as against 2.5 million calories produced by a feddan of wheat. Area under vegetables and fruits should be increased to make such protective food available at a cheap price to the poor people.

The annual income of our animal wealth is 60 million pounds. The total number of the Egyptian cattle is over 2 millions, but the production of milk is not sufficient. These animals should be used for producing milk and meat rather than for work. This needs an increase in the mechanical means of agriculture. Fodder occupies 23 % of the cultivated area, and this is quite enough to support the 2 millions heads of cattle, but better types of animals are required. Some attention can be devoted with advantage to animal husbandry, both in regard to meat and dairy produce. It has been estimated that if the cotton-seed cakes, which are exported, were used as fodder for cattle in Egypt for meat production, the profit would be 60 % over that derived from exporting that valuable animal food. On the other hand, a saving of nearly one million pounds in the imports could be effected through the development of dairy and poultry farming.

III. Increasing efficiency of production :

Although the output per feddan in Egypt is higher than it is in many other agricultural countries, it is still less than it should be. The increasing of this output should be based, as our Minister of Agriculture has mentioned, on four technical pillars : (1) production of selected seeds; (2) availability of favourable environment; (3) prevention of loss caused by pests and (4) reduction of production costs. Continuous researches in connection with Egyptian cotton have produced breeds with high yield per feddan. These researches should be extended to all other crops cultivated in the country. The land of Egypt has not been yet properly studied to determine its fitness for at most production. The soil should be thoroughly surveyed, and necessary measures for maintaining its fertility should be taken. The Ministry of Agriculture has undertaken, during the last three years, a comprehensive study of the soil fertility and the methods of raising its productive capacity. Investigations have been made to determine the water requirements of each crop, and to discover the effect of the underground water in the growth and yield of crops. The loss in crops has been estimated at 13 % in cotton, 10 % in wheat, 12 % in maize, 3 % in rice, 33 % in onions and 10 % in sugar cane. Preventive measures have been taken, but they should be applied on a wider scale to combat the diseases and pests and to protect plants and animals.

But, finally, whether the country's efforts are directed towards a more varied production, or to the improvement in the yield of existing crops, it seems unlikely that agriculture alone will afford an outlet to the increasing population in Egypt. Industry has made a successful start, and the deficiency of coal is more than counterbalanced by the cheapness of electricity, provided by the High Dam project. We have cheap labour and abundant raw materials. The success of various modern Egyptian industries points out to the fact that, unless the birthrate falls and the population of the country is maintained at a manageable level, industrialisation will be the only solution to Egypt's population problem.

Cairo, 30th December, 1955.

DEVELOPMENT OF MAP REPRODUCTION
IN THE SURVEY OF EGYPT [1]

BY

M. A. ETEBA & A. F. SALAH
(SURVEY OF EGYPT)

In printing there are three principal groups :

1) Relief Printing, in which the drawing stands up to a certain height and all else is at a lower elevation. A roller with pigment on it passes over the raised surface, and paper is then pressed on it, touching only the raised and pigmented portion. Typical of this is wood-engraving.

2) Intaglio, in which the design is cut into a flat surface which, having had pigment applied all over it, is wiped or cleared off the face leaving pigment in the recessed desine. The print is then taken by pressing paper over the whole surface with soft backing, so that the pigment is picked out of the recesses. Typical of this is copper plate engraving.

3) Planographic, in which the design is different in nature from the plane surface on which it is formed, so that the pigmented roller passed over the whole surface delivers pigment only on the design. The paper is then passed on the whole surface and only the pigment from the design is transferred to it. Typical of this is lithography.

It is the third group which is generally applied in map reproduction. Lithography has evolved from the natural antipathy of grease to water. In the olden days the limestone known as lithographic stone on which the drawings were made by litho crayon or litho ink was used. Although stone remains the most versatile and attractive surface on which to draw,

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[1] Paper delivered at the International Geography Seminar, held at the Muslim University of Aligarh, India, January 9-16, 1956.

most work is now printed from zinc sheets which made the « Offset Litho » process much easier.

Nowadays, the application of photography to lithography has been proceeding apace and has now reached the stage where « Photo-litho », as it is generally termed, is not merely a minor branch of reproduction work but a craft or process taking precedence in all modern lithographic houses. The old method of preparing metal press plates by direct drawing is now almost entirely superseded by photo-mechanical methods which reproduce every detail in the copy. The process is not of course entirely mechanical, the final results depending on the skill and experience of the operators and artists employed in the several stages. The general procedure is briefly summarized as follows :

The original to be reproduced is placed on the copy-board of a specially constructed camera and usually illuminated by powerful arc lamps (in the Survey of Egypt natural daylight is used in this phase of the work). The image is focussed to the correct size and a negative made which in the case of a line subject would consist of perfectly clear lines on an opaque ground. The grained litho plate which is to receive the photographic impression is thoroughly and chemically cleaned and coated with a light-sensitive albumen solution. A special whirling and drying machine is employed to spread and dry the coating evenly. The plate with the negative in the required position is placed in a vacuum frame which in operation firmly presses the negative film into close contact with the plate surface. The surrounding area of the plate is protected from light and then an exposure is made. This renders the sensitive albumen coating immediately beneath the clear portions of the film insoluble in cold water. The whole surface of the plate is coated with a thin film of tenacious ink similar to a combination of litho ink. Immersion in cold water permits the washing away of all portions of the albumen film which have been protected from the action of light by the opaque portions of the negative, leaving on the plate an extremely strong and perfectly sharp image consisting of a hardened albumen base with an acid-resisting ink surface. A special negative, and consequently a special plate, is prepared for every base-colour. Thus, if a map consists of the following base-colours :

1) black for names, frame and graticules;
2) red for roads;
3) blue for rivers and canals;
4) brown for contours;

the original drawings of these four items are drawn in black, superimposed on a board and photographed to give the final plates.

Coast and Geodetic Survey, U. S. A. is using a further developed process known as « Glass Negative Engraving ». It is claimed that : « this method produces accuracy and quality and in some respects greater than copper engraving. Its advantages over the method of preparing drawings with pen and ink are many. A quality that cannot be equaled, and its economy are the principal advantages. Those who have endeavoured to produce fine work with pen and ink understand the difficulties encountered in the effort to produce uniformity of lines. The proper pen point, the ruling pen, the swivel pen; each require constant care in the attempt to secure a uniform flow of ink on the drawing. Also every effort must be made to ensure that the work is always black in order to provide suitable copy for the photolithography. The character of the paper on which the drawing is made seems always an obstacle in securing fine and uniform black work, especially if colour separation is required on blue line prints on mounted paper. In contrast to these difficulties is the ease with which this work can be accomplished in negative engraving. Steel points in special tools provide uniformity without effort for any character of work ».

The trouble with this method is that the draughtsman has to work on the same scale of the final printing, while in the usual method he works on enlarged originals which, of course, is easier.

But a complete map has usually some coloured layers to give the impression of different elevations and other colours, say, for seas, sands ...etc. The plates necessary for such colours can be obtained by transferring the impression of the details from a key plate by means of set-off powder. The areas of the required colour is then filled in by hand with litho ink and the rest of the plate is gummed. Sometimes, when required, screens are used to give ruling and cross-ruling areas. The trouble with the set-off plates is that they are hand drawn on the pure

metal without the hard albumen base. Consequently, the set-off plate will be spoilt rapidly in the printing machine and another plate must be hand-drawn again.

Experiments were carried out in the Survey of Egypt to overcome these difficulties. The effort was concentrated on making one negative (and consequently one plate) for the different tones of one colour as in the case of contour layers. It was easier to photograph one good negative to six of these layers instead of making six separate plates as in the case of preparing for 1/100,000 topographical maps. This is accomplished by placing a « half-tone screen » immediately in front of the sensitive plate which splits up the image into dots of equal density but varying in size corresponding to the tone of each layer. This procedure, not only helped to use one plate for more than one tone but also made it possible to make these tones on the hard albumen base, and to get a new printing plate immediately when one is exhausted. The coloured originals of the layers are prepared either by standard poster colours or by air-brush.

In order to cut down the cost and to save time, a trial was made by paper graduated in colour from light grey to dead black. The appropriate tone of paper was cut and stuck to the corresponding layer until the original of one colour was composed of different tones of coloured paper. This original was then photographed using a half-tone screen and an albumen printing plate was prepared.

THE NEED FOR REGIONAL PLANNING IN EGYPT

BY

DAWLAT A. SADEK.

The major problem facing the world to-day, is that of developing its resources to satisfy the demands of an ever-increasing population. The demand is not only for a bare subsistance (though indeed many millions are still deprived of that), but for a constantly improving standard of living. This has to be achieved from a land area which remains relatively fixed and limited in its potential. It is true that there is still much undeveloped potential, but it is difficult to see. This being developed at the rate of the demands made upon it—certainly not if the process is left entirely to the chance operations of a « free market ». The only hope lies in consciously planner development. And this calls for planning on a regional basis.

This lesson is brought out clearly by Professors J. S. Allen and C. F. Riley in their article « The Dynamics of Regional Planning » [1].

« *Throughout the world to-day there is a growing appreciation of the need to plan on a regional basis. This is true of the countries which are highly industrialized and heavily populated and of the less developed countries based on a subsistance or otherwise retarded economy. In all cases the Fundamental problem is the same : it is that of making the most effective use of land resources in relation to a given population. The nature of the problem in almost every case is such that it can only be solved within the framework of a sufficiently large planning unit embracing varied resources and an adequate population in terms of size and productive potential. Essentially the objective is that of deploying, or re-deploying, population in relation to existing and potential resources with a view to efficiency in production and distribution coupled with*

[1] *Planning Outlook*, vol. III, N° 4.

the creation of an environnement which is conductive to satisfactory living conditions for the individual and the community........... This means that in any given set of circumstances the objectives of regional planning, if they are to be attained, have to be brought to the level of practical politics and tailored to meet the determinant physical, economic and social conditions of the particular area under consideration.»

Many of the lesser developed countries where the demand for regional planning is becoming vocal and can rely, in many cases, on the conscious and effective support of powerful sections of the population.

This is true of Egypt where the present Government is obviously fully active to the need for large-scale planning. The will is there, and it is now a matter of developing the techniques.

Clear consistant policies must be applied for the public benefit and for the protection of legitimate individual rights, backed by public opinion.

This article is devoted to a consideration of some of the principal issues likely to arise in the framing of regional plans for Egypt.

The technique of regional planning should be applied in Egypt both to town and country-side as they are inseparable, both geographically and socially, and the establishment of the fundamental facts concerning their inter-relations by means of survey and analysis of all the relevant urban and rural factors is a condition precedent to success in the social and economic planning to which we are committed in this post-revolution time. Towns cannot be isolated, whether for study or for treatment by planners. They do not exist « in vacuo », cut off from the contiguous areas along clear-cut municipal boundary lines. On the contrary towns are always fundamentally related to areas which are greater in extent than the mere sites they occupy.

The natural resources of Egypt as a whole may be studied under :

a) Mineral deposits;

b) Land;

c) Water supplies (irrigation, and water power).

The Libyan desert which makes up the greater part of the surface of Egypt consists in the extreme south of the ancient metamorphic rocks and granites of the great African Massif. North of the southern outcrops

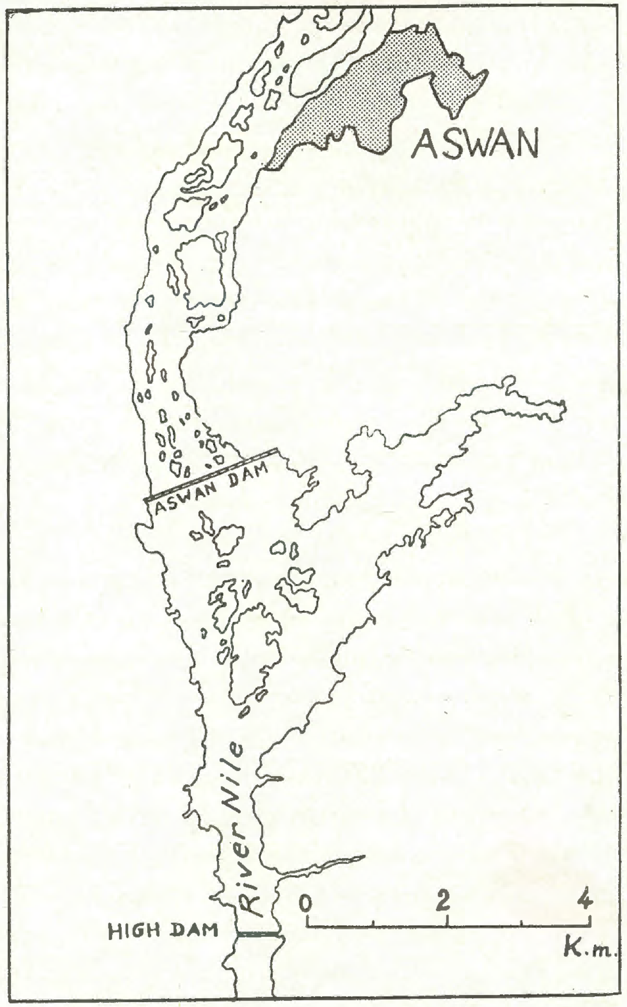

Fig. 1. — Map of Aswan Region.

of ancient rocks are found the wide stretches of Nubian sandstone, then northward wide expanses of Limestone. Apart from this northern part the Libyan desert appear, to offer but little scope for development unless oil is found there.

The Eastern desert is naturally attached to the Sinai Peninsula. Its surface is much more varied and has in many places considerable natural

resources. There are precious stones, notably the famous turquoise, some deposits of phosphate rock and nitrate and the small but significant oil fields which have long been worked along the western shores of the Gulf of Suez. There are also salt deposits and building stones such as granite, sandstone and porphyry.

The Nile Valley, the third geographical region of Egypt, stretches from the south just north of Wadi Halfa as far as Cairo. Below it the Nile devides into its distributors which pass through the Delta on their way to the Mediterranean.

The fertile land of the valley and the delta have been deposited by the river. The Nile itself runs between parallel lines of cliffs, in some places only 220 yards wide, but normally a few miles apart. The alluvial soil, the most fertile soil in Africa, consists of the debris of Abyssinian basalt.

Water supplies in Egypt are a fundamental problem. They are essential to agricultural crop production, are a potential sources of power, and are, of course, essential to mere existence.

The use of irrigation as an aid to cultivation began almost certainly in Egypt, where there is clear evidence that prior to 2.000 B.-C., the inhabitants were accustomed to baling water from the river on to their farmed plots. Canal construction for widespread irrigation during time of flood is also a practice of long standing in Egypt, where it is associated with the system of «basin» irrigation—as distinct from perennial irrigation, a very much more recent innovation.

The perennial system in Egypt depends on two principles of water utilisation : one, the artificial damming of the Nile during flood; the other, the storage of water in reservoirs for use during the low Nile, making possible two and, more rarely, even three crops per annum from the same plot of land. So extensive now is the range of perennial irrigation that it serves about 80 per cent of the agricultural land of Egypt.

Irrigation and hydro-electric schemes, where they are a practical possibility, therefore loom large in regional development projects. The various construction and distribution schemes of the High Dam at present under way, in Aswan, region, will lead to hydro-electric power in great quantities in the very near future.

Egypt has long been known as a zone of excessive population pressure. The fundamental fact of the geography of Egypt is that her habitable area consists of no more than the narrow valley, its delta, and a few scattered oases.

Egypt's population is now 22 millions, barely a quarter of it being urban. The last census, taken in 1947, recorded a population of 19.1 millions and revealed that the population had doubled itself in fifty years [1]. Population increase has outpaced the expansion of agricultural land, for the population has doubled since 1897 while expansion of farmland has only been 13 per cent and the crop area 33 per cent. Greater intensification of farming and widespread use of artificial fertilizer have helped to raise the productivity of that land, but living standards have fallen; the law of diminishing returns is slowly becoming operative [2].

Attempts have been made to demonstrate and assess the amount of surplus population in Egypt. It has shown that the total volume of agricultural production could be produced easily by half the existing rural population—that is, at a conservative estimate, at least 6-7 million fellahin are redundant. This astonishing conclusion is drawn from experiments based upon existing conditions of husbandry, wasteful of labour. With the bettering of the health of the fellah as hygiene and sanitation improve, and the consequent raising of this work capacity, so will the proportion of « surplus» rural population increase. It is this very great excess of rural population which keeps down the standard of living. Consequently there is widespread under-employment in rural Egypt. The towns also have a « surplus» element in their population; but since the urban population is barely 25 per cent of the total population, the major problem lies in the rural areas.

The unequal distribution of land ownership in Egypt was one of the causes of poverty and social unrest. After a cadestral survey in 1813 Mohammed Ali divided the cultivated land among the farming population, each small farmer being allotted between 3 and 5 feddans. But,

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[1] A. B. Mountjoy, *A note on the 1947 Population of Egypt.*

[2] C. Issawi, *Egypt : an economic and social analysis* (1947), table X, 55.

in addition, large areas of unreclaimed land were awarded to men of position, for a time tax-free, conditional upon their being put into cultivation within a certain period. Favoured by the Moslem law of equal inheritence this process has continued steadily; in the last fifty years the number of landowners has almost quadrupled although the total land owned has increased by only 18 per cent.

The large holdings appear to have suffered much less from fragmentation than the medium and small holdings. This is because some are owned by religious bodies and land companies, and not by individuals.

Before the revolution in Egypt, we found that 6 per cent of landowners share two-thirds of the land and that some 12.000 individuals own 36 per cent of the land, whereas 2 millions peasant owners share but 14 per cent, in plots averaging but two-fifths of an acre each [1]. In addition there is a growing class of landless peasantry.

In Egypt the solution to the population problem was frequently dismissed lightly as being merely the bringing into cultivation of unreclaimed areas and by completing the conversion from basin to perennial irrigation, which would allow summer crops to be grown on the 950.000 acres of basin land in Upper Egypt. It must be appreciated that all schemes for expanding Egyptian agricultural land depend upon the availability of water; Reservoirs of the seasonal storage type, like Aswan Dam, will be unable to conserve sufficient water in the future to supply these maximum demands, which can be met only by development of the now famous plans of the High Dam for over-year storage. No large-scale conversion to perennial irrigation seems possible until there is built the new large storage dam the « High Dam » included in the over-year conservation scheme. Such a dam can then assume the safety-valve function of the present basin lands [2].

With the shrinkage of the basin-irrigated area, there is occuring in Egypt a hardening of opinion against perennial irrigation. It is pointed out that whereas basin irrigation enriches the soil each year, perennial

(1) From *Annuaire Statistique de Poche,* 1949-1950 (Cairo, 1951), table 41.
(2) Fig. 1.

irrigation impoverishes it and allows the bulk of the fertiles alluvium to run to waste. It necessitates the widespread use of expensive artificial manures and at the same time creates conditions favourable for the spread of debilitating diseases, from which the fellahin of Upper Egypt so far are remarquably free. Moreover, the perennial canal system is expensive to create and also brings costly drainage problems. Its chief merit is, of course, that it makes possible the large-scale cultivation of cotton, now the foundation of the Egyptian economy.

The development of industry as a means of raising income per head is frequently cited as a remedy for agrarian over-population. In Egypt manufacturing industry has developed mainly since 1930 and enjoys a high measure of tariff protection. This has the effect of permitting a continuance of high-cost production. With the principal exception of textiles the bulk of Egyptian industry is of small-scale, virtually workshop-nature; 92 per cent of « industrial establishment » in 1948 each employed less than five workers. Such a structure indicated a low degree of mechanization with few of the economies possible to large-scale modern factory units : it is a structure that favours high-cost production.

In Egypt it is claimed that industry is of value as a means of absorbing surplus population and of raising the standard of living, but these claims are scarcely borne out by the facts. Twenty years after protection was first granted, the number employed in all form of industry, mining and construction has risen from 620.000 to c. 900.000. The population has increased by well over 5 millions in this period, and the annual population increment is now at the order of 300.000. From these figures it is obvious that, so far, industrial activities have played but a negligible part in absorption of this population increase.

Future industrial development is hampered by the limited size of the home market, the high-cost of raw materials and fuel, and, finally, the lack of trained managenial and administrative personnel. Some of these difficulties will soon diminish as time passes by using the hydro-electric power from the high-dam, the expansion of the market by sending the products of Egyptian industries to the Arab world, and the Vocational Training Centres. The industry will, one hopes, expand to a marked degree particularly now that a separate Ministry of Industry

has been established. The high authorities in Egypt now are fully aware of the great need of industrialization of the country.

On the question of industrialization, Professors Allen and Rily have this to say : « Whilst one can make a conscious effort to avoid the mistakes of nineteenth century industrialization in the western world, it must be appreciated that there are dangers in attempting to buy-pass phases in that development, and it must be constantly borne in mind that industrialization can only be fully effective if it is regarded as an integral part of the wider process of economic development. The initial step is that of raising the productivity of the workers engaged in the primary activities of agriculture or the winning of minerals, but having achieved that, further increases in average productivity can only be secured by transferring labour to other employment not only in the secondary industries of processing and manufacturing but also in the tertiary occupations of commerce public services etc. The problems are likely to be most acute in the underdeveloped countries with heavy population pressure, rather than in pioneer economies where the problem is basically one at shortage of man-power in relation to given resources».

On the matter of countries of the first category the United Nations Report on the « Processes and Problems of Industrialization in the Under-developed countries» makes the following important point—« In countries in which labour is abundant in relation to natural resources, secondary industry can perhaps be manned by under—employed workers from rural areas, and the effort to raise agricultural output pressed forward simultaneously with the extension of industrial activities».

Above all it should be remembered that industrialization is not an end itself—the real aim is to raise the average standard of living.

Agricultural reform alone will not achieve this in Egypt. Industrialization also required, but such industrialization can only be achieved by complementary changes in agricultural production designed to raise the purchasing power of the fellahin and so provide the necessary expansion of the market for the products of Egypt's industry, whilst at the same time, developing agricultural production to meet the needs of increasing urban population with a rising standard of living. These are large problems and by no means easy of solution, but it is a challenge

which we must face and one of the most important means we can have at our disposal in tackling the problem rationally is through the development of effective regional planning techniques.

The essentials of success are the necessary raw materials and other natural resources, and other capital equipment, the right amount of labour both qualitatively and quantitatively (at all levels-unskilled, skilled, supervisory technical and managenial) to achieve the transformation, and all must be backed by the necessary spirit of enterprise.

Physical development plans must be linked with the land reform policy as a necessary condition of economic and social progress. Otherwise, defects in the agrarian structure are almost certain to render arborative any attempts at development in other fields. Even with a really sound agricultural economy the obstacles to industrialization will be formidable enough.

Taking Aswan region as an example, it will, within the next few years, be transformed from an agricultural region into one of the most important sources of industrial raw material in Egypt. Its rapid industrialization will be based primarly on the large deposits of iron-ore. The exploitation of the iron resources and the development of the chemical industry will make it an important factor in the industrial life of the country. The various construction and distribution schemes of the High Dam at present under way, will lead to hydro-electric power in vast quantities in the very near future. Geographically speaking however, before this new source of power can be put into use, much remains to be done as regards accommodation for workers and communications.

Adequate communications are very essential to success, without them an adequate market economy cannot be created, and it is necessary that the whole net-work serving not only industrial production but also agricultural production and general distribution should be efficient.

The need for large-scale regional planning is clearly evident for this area. However, the survey would not be concerned merely with the internal affairs of the region. The latter has economic ties with the most densely populated and the most highly industrialized areas of Egypt, to which it will send electricity and iron. It is a region whithin which there is a need for social as well as economic integration and planning.

Although the iron resources are in Aswan region together with the scheme for hydro-electric power, yet it would appear better to locate the secondary processing at a distance from Aswan for several reasons.

Primarly, the establishement of boundaries in the immediate neighbourhood of Aswan could ruin the projected plans for the development of Aswan as an influential winter tourist and health resort. Such a project would in itself create a most important form of development for the area, providing both income and a market for rural crafts and would raise the local standard of living.

Secondly, the temperature is exceedingly high during a large part of the year and this will be detrimental to the health and the capacity for work of the employees. Again, the cultivable land is so narrow in Aswan region that it will not ensure a large enough supply of food for the population of the industrial area.

Finally, both Limestone and coal are needed to transform the iron ores into rion and steel, and the nearest limestone is fifty kilometers North of Aswan.

Factories for smelting ore are now being built in the neighbourhood of Helwan, where not only the iron ore of Aswan, but also that of Bahariya oasis could be worked. The site is additionally convenient from the point of view of the health, comfort, and efficiency of the workers.

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In the field of regional planning piece-meal planning spells disaster. The planning must be comprehensive in the full sense of the word. There must be the closest possible partnership between the economic planner, the land use planner and the various other experts whose service will be necessary at different stages in the planning process. Major changes will be involved in all aspects of the social and economic life of the community. Schemes for the advancement of health and education, development in public services and public utilities, all are involved and the prime necessity is effective coordination. This is true not only of the truly backword areas but also of such countries as Egypt which has a great deal of technical knowlegde available within the country itself but is handicapped in other ways and requires to make the utmost effective use of its internal resources by the rational application to the resources of its own knowledge and skill and, as far as practicable, its own capital with a limited amount of specialized technical advice on the planning site from foreign experts.

The role of the geographer in planning is to help in the appraisal of conditions, to assist by the interpretation and correlation of date; and to present regional accounts that act as a focus of both national and local viewpoints. This latter task is by far the most important—for unlike the simply technical nature of the first two jobs, the presentation of regional accounts involves the weaving together of these separately studies strands into balanced views of complete regions.

The humanised landscape presents a complexity that requires patient study and a particular outlook to appreciate. This is where the geographer can help in more than the modest and indeed obscure role which to date he has performed.

Whatever may be the principles upon which planning is founded, the question of scale inevitably arises. Geography, through showing many sides in different schools aims in the end at seeing and understanding the world in regions. And in this lies the geographer's major contribution to the wider sphere of regional planning.

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LE DJEBEL ANSARIEH

ÉTUDE MORPHOLOGIQUE

PAR

ÉTIENNE DE VAUMAS

SOMMAIRE

A regarder une carte à moyenne échelle, aucuns massifs parmi ceux qui bordent la côte de la Méditerranée orientale ne se ressemblent plus que le Djebel Ansarieh et le Liban.

Tous les deux sont allongés le long de la mer, celui-ci en contact étroit avec elle, celui-là un peu plus dessoudé d'elle, mais à peine. Leur orientation est très voisine : le premier s'allonge du Nord au Sud, le second du N.-N.-E. au S.-S.-O. Malgré l'ampleur du seuil qui les sépare et qu'occupe le Nahr el Kebir méridional, on devine qu'ils se prolongent l'un l'autre. Le fait est évident au point de vue orographique ; la vue de la carte géologique, même à petite échelle donne l'impression qu'il en est de même au point de vue structural. La topographie d'ensemble se présente aussi de façon semblable ; tous les deux dressent en face de la mer une façade très large tandis qu'ils retombent de manière brusque vers l'intérieur ; tous les deux également sont sabrés de ravins profonds, situés presque côte à côte au Djebel Ansarieh, moins nombreux au Liban, mais cloisonnant dans les deux cas la montagne où l'on devine que les communications longitudinales sont pratiquement impossibles.

Seule différence à peu près nette qui ressort d'un premier examen d'ensemble, le Djebel Ansarieh est plus étroit, moins massif que son grand voisin du Sud : il ne mesure que 130 km. de longueur et sa plus grande largeur ne dépasse pas 40 km. alors que le Liban atteint 170 km. du Nahr el Kebir méridional au Nahr Qasmié et que sa largeur se hausse jusqu'à 46 km. Une prospection rapide montre également que le matériel rocheux mis en œuvre dans l'un et dans l'autre est similaire et consiste principalement en calcaires jurassiques et cénomaniens.

Limité au Nord par le couloir du Nahr el Kebir septentrional, au Sud par le seuil Homs-Tripoli (Nahr el Kebir méridional), à l'Ouest par la Méditerranée et à l'Est par le Rhâb, la cuvette d'Acharné, le plateau de Massiaf et celui du Waar, le Djebel Ansarieh a donc toute chance de révéler une structure et une morphologie pareilles sous de nombreux rapports à celles du Liban. A ce point de vue là, son étude détaillée n'est pas très enthousiasmante pour celui qui l'aborde avec l'intention de voir tout de même plus clair dans la réalité qui effectivement, comme on le verra, correspond bien à l'impression première qu'on pouvait s'en faire.

Mais, outre qu'il est utile et nécessaire d'inventorier systématiquement les régions géographiques, même celles qui a priori ne paraissent pas devoir amener à des conclusions générales très nouvelles, il se trouve que l'étude du Djebel Ansarieh s'est révélée fournir des enseignements qui ne valent pas seulement pour sa propre interprétation mais aussi pour celle des régions avoisinantes. Certains grands problèmes comme celui de la structure longitudinale de la Bekaa, n'ont pas leur principe de solution au Liban mais plus au Nord dans le Djebel Ansarieh et notamment dans l'évolution du Djebel Helou qui flanc-garde celui-ci au S.-E. La recherche s'y montre donc finalement payante.

Habité par des minorités restées longtemps à l'écart de l'ensemble de la population syrienne, le Djebel Ansarieh a fait l'objet d'une thèse de géographie humaine parmi les plus brillantes qui ait jamais été écrites [1]. Après quinze ans qui se sont soldés par une évolution déjà marquée de cette contrée, la description de J. Weulersse demeure la meilleure entrée en matière pour celui qui veut se familiariser avec la géographie du Djebel Ansarieh.

Sous l'angle de la géographie physique, la connaissance de cette montagne était encore à peu près nulle malgré l'existence d'une bonne cartographie qui couvre tout le pays [2]. Les matériaux de base ne manquaient pas cependant. L. Dubertret avait eu le mérite depuis une vingtaine d'années déjà de débrouiller la stratigraphie et de dresser la carte géologique d'une région qui était demeurée jusque là un no-man's land [3]. Bien que s'étendant moins sur les phénomènes structuraux que sur les faits plus proprement géologiques, cet auteur a vu

[1] **1**.

[2] Voir plus bas, p. 262. La carte au 1/200.000e est achevée pour tout l'ensemble de la région. Deux feuilles seulement (Safita et Qalaat el Hosn) manquent à la carte au 1/50.000e pour être complète.

[3] Voir principalement : **8**, **9**, **10** et la cartographie géologique, *infra*, p. 262.

dans le Djebel Ansarieh un horst où les failles jouent le rôle essentiel.

Il restait à analyser cette structure de manière plus détaillée et à en décrire la morphogénèse comme les formes qui en sont dérivées, celles-ci n'ayant jamais fait l'objet d'aucune recherche ni d'aucune description.

C'est à cette tâche que nous nous sommes appliqué durant trois étés passés sur les lieux (1953, 1954, 1955). Les premiers résultats concernant la morphométrie et surtout les terrasses d'abrasion marine ont déjà été publiés [1] et il n'en sera donc plus question dans le présent mémoire. Celui-ci voudrait simplement faire le bilan de la structure et du relief du Djebel Ansarieh [2], réservant à plus tard les questions de morphologie climatique qui ont avantage à être traitées dans un ensemble géographique plus vaste.

§ I. L'HISTOIRE GÉOLOGIQUE ET LA SÉRIE STRATIGRAPHIQUE

La série stratigraphique du Djebel Ansarieh est intéressante au double titre de ce qu'elle nous apprend du passé de ce massif et des roches qui le composent, points de vue qu'il faut examiner successivement avant de passer à l'étude plus proprement géographique de la structure et du relief.

I. Première esquisse de l'histoire géologique du Djebel Ansarieh [3]

L'analyse des dépôts qui se sont effectués au cours des âges sur l'emplacement du Djebel Ansarieh, est bien loin de permettre de retracer l'histoire du massif dans tous ses détails, — surtout l'histoire récente pour laquelle on verra que la structure et la morphologie apportent des compléments essentiels, — il n'en reste pas moins vrai que par les faciès que revêtent ces dépôts comme par les lacunes qui existent dans

[1] **21, 22, 23, 24.**

[2] Les principaux résultats ont déjà fait l'objet de deux notes : **27, 28.**

[3] La matière de ce paragraphe ne fait que résumer les connaissances stratigraphiques actuellement acquises. Voir principalement : **8, 9, 10, 14, 17.**

leur succession, elle permet de dresser déjà une fresque d'ensemble de l'évolution de cette montagne.

Le socle qui soutient celle-ci ne se montre nulle part. Aucune couche primaire, triasique ou liasique n'y a été signalée, ni ne le sera jamais. Les couches les plus profondes que laissent voir les gorges creusées par l'érosion sont en effet du Jurassique, plus précisément du Jurassique supérieur quoiqu'il ne soit pas impossible que des assises du Jurassique moyen soient découvertes un jour à la base de celui-ci comme le cas s'est produit au Liban durant les dernières années.

A cette époque, l'emplacement du Djebel Ansarieh à l'image de toute l'étendue actuellement occupée par les autres massifs levantins était recouvert par une mer profonde. C'est celle-ci qui a donné l'énorme masse de calcaires qui serviront plus tard d'armature à la montagne, calcaires d'une dureté généralement uniforme quoique quelques couches dolomitiques plus tendres s'y rencontrent dont les plans de stratification sont souvent très malaisés à discerner. Ce n'est que vers le haut de la série que des faciès plus bréchiques apparaissent, annonçant une émersion commençante.

Le début du Crétacé (Néocomien) correspond en effet à une exondation totale à la différence de ce qui se passe au Liban où elle n'est que partielle et intermittente. Il en résulte que les grès et les sables de cet âge, si typiques de la montagne libanaise, sont complètement absents du Djebel Ansarieh.

Cet épisode ne dure pas car le reste du Crétacé correspond à un nouveau cycle sédimentaire. Amorcée à l'Aptien et à l'Albien, cette transgression atteint son apogée au Cénomanien pour s'achever au Turonien et au Sénonien.

Les couches inférieures sont assez diversifiées et dénotent une instabilité du fond de la mer. A Mechta Helou (Djebel Ansarieh méridional), on voit ainsi de la base au sommet : de la marne argileuse avec des bancs de calcaire marneux (8 m.); des calcaires détritiques, glauconieux, ocre foncé, en petits bancs; un gros banc de calcaire blanc (12 m.) qui prolonge la falaise aptienne du Liban; enfin de l'argile verte (10 m.) qui est peut-être déjà albienne. La puissance des couches attribuées à l'Aptien ne dépasse pas 30 à 40 m. d'épaisseur. L'Albien avec sa

marne gréseuse verdâtre, ses calcaires en gros bancs, ses coulées basaltiques interstratifiées mesure environ 170 m.

Au Djebel Ansarieh comme dans tous les autres massifs levantins, ce sont les alternances de calcaires compacts et de dolomies du Cénomanien qui, après les assises du Jurassique, ont fourni le plus fort tonnage de matériaux. Leur épaisseur a été estimée à 350 m., il semble bien qu'en moyenne, elle est supérieure à ce chiffre et se situe dans les 500-600 m. [1].

La fin du cycle s'annonce dès le Turonien dont les couches sont quasi insignifiantes. Il s'achève au Sénonien durant lequel se déposent de 100 à 150 m. de craie qui ne se retrouve plus qu'à la périphérie du massif. Cette localisation est-elle due à une émersion dès cette époque ou bien à la dénudation qui a suivi celle-ci? Il n'est pas possible d'en décider dans l'état présent des connaissances stratigraphiques.

L'absence complète de l'Eocène inférieur montre en effet de manière indubitable l'existence d'une première phase orogénique au début du Tertiaire, bientôt interrompue par un retour de la mer.

La transgression lutétienne, à la différence de celle du Crétacé, ne fait plus cependant que border le noyau central du massif qui reste exondé. Ses traces sont nombreuses dans le Djebel Ansarieh septentrional où les calcaires durs de l'Eocène moyen jouent un rôle important dans le relief. Un témoin en a été signalé dernièrement dans le Rhâb au pied de l'escarpement qui domine celui-ci [2]. Dans le Djebel Ansarieh central, un affleurement en existe encore sous les laves du Markab un peu au Sud de Banias. Par contre, le Nummulitique disparaît complètement tout le long du Djebel Ansarieh méridional.

A l'extrémité Nord de la montagne, la transgression nummulitique dure plus longtemps. Des marnes blanches, très semblables à la craie sénonienne, succèdent aux calcaires lutétiens; elles dénotent dans cette région une durée plus longue du séjour de la mer qui effectivement se poursuivra même durant l'Oligocène dans le Kosséïr voisin.

(1) Sur les coupes, on a adopté une épaisseur moyenne de 500 m., chaque strate dessinée équivalent à 100 m.

(2) 30.

Dans l'ensemble cependant, l'Oligocène, comme le Burdigalien après lui, marque un retrait généralisé de la mer, une nouvelle phase orogénique, — la deuxième, — s'exerce alors et accentue la tendance à l'émersion qui s'était déjà affirmée à l'Eocène inférieur.

Cette accentuation est bien soulignée par le fait que la transgression vindobonienne qui lui fait suite, pénètre beaucoup moins loin que ne l'avait fait la transgression lutétienne. Nulle part, les calcaires et les marnes de cet étage ne dépassent les premières pentes de la montagne. Assez continus au N.-O. du Djebel Ansarieh, ils s'effacent complètement sur la bordure de ses parties centrale et méridionale. Aucun témoin ne s'y rencontre plus. Le phénomène est d'autant plus remarquable que le Vindobonien affleure largement un peu plus au Sud le long du Liban en arrière de Tripoli.

Au Pontien, le recul de la mer est général et dénote par conséquent l'existence d'une troisième phase orogénique. Aucuns poudingues de cette époque n'ont encore été découverts à l'Ouest mais à l'Est on vient d'en signaler [1] qui sont probablement de cette époque.

Avec le Plaisancien, se produit une dernière offensive de la mer qui s'insinue entre Djebel Akra et Djebel Ansarieh. Ses dépôts se retrouvent tout le long de la côte jusque vers 200 m. d'altitude. Dans le Kosséïr, les argiles gris-bleues s'ensablent vers le haut. Dans le golfe de Lattaquié, elles sont couronnées par des alluvions continentales vers 240 m. Dans le Djebel Ansarieh méridional, elles s'interstratifient dans une grande nappe basaltique qui les recouvre parfois [2]. La fin du Pliocène est donc marquée par l'émersion définitive due à une phase orogénique — la quatrième — qui s'accompagne d'un volcanisme intense.

II. Premières conclusions

Cette esquisse rapide de l'histoire du Djebel Ansarieh autorise déjà un certain nombre de conclusions qu'il importe de dégager déjà d'une manière plus précise.

(1) 30, 31. (2) 5, 12.

1. *Âge de la constitution des massifs.*

C'est dès la fin du Secondaire qu'apparaît la première ébauche du Djebel Ansarieh. Au Sénonien peut-être, à l'Eocène inférieur certainement, le premier noyau de la montagne actuelle émerge définitivement.

Les transgressions du Tertiaire ne feront plus que border par la suite ce réduit et elles ne le feront plus que de manière de plus en plus lointaine ce qui souligne bien que le massif prend de plus en plus, d'ampleur à chaque exondation.

Les périodes d'émersion correspondent en effet à des phases orogéniques que révèlent les discordances des dépôts de chaque époque par rapport à ceux de l'époque antérieure. Elles posent déjà le problème de pénéplanations anciennes que l'on retrouvera par la suite. Cette hypothèse est d'autant plus vraisemblable que la simultanéité des orogénèses du Djebel Ansarieh et du Liban laisse supposer que leur histoire morphologique a de grandes chances d'être semblable.

2. *Position des rivages du Tertiaire* (Figure 4).

La position des rivages du Lutétien, du Vindobonien et du Plaisancien souligne le fait que l'emplacement du massif est toujours resté constant. C'est autour de son noyau actuel que s'ordonnent les transgressions tertiaires. Le fait est suffisamment évident pour qu'il soit nécessaire d'y insister.

Un autre point par contre mérite d'être souligné. Tout le long des massifs syro-libano-palestiniens, les transgressions sont de moins en moins importantes au fur et à mesure qu'on se rapproche de l'époque présente. La mer vindobonienne s'est avancée moins loin que la mer lutétienne, et la mer plaisancienne est en retrait sur celle du Miocène. Or, au Djebel Ansarieh, ce schéma est mal respecté.

Le rivage lutétien bordait l'anticlinal jurassique dans le Djebel Ansarieh septentrional, il longeait aussi le Djebel Ansarieh central, mais de là passait certainement très au large dans la baie d'Akkar puisque ce n'est qu'à la hauteur de Saïda qu'il reprend contact avec la montagne libanaise.

Le rivage vindobonien dans le Nord du Djebel Ansarieh est nettement en retrait sur le précédent et lui reste extérieur dans les parties centrale et méridionale de la montagne. Par contre, il le déborde à partir du Nahr el Kebir puisqu'il vient en arrière de Tripoli au contact même du Liban dans une région où les dépôts du Nummulitique sont inconnus.

Le rivage plaisancien montre des phénomènes semblables. Situé plus à l'Ouest que le littoral vindobonien dans le Nord du massif Ansarieh, il chevauche largement non seulement le littoral vindobonien mais encore celui du Nummulitique dans tout le secteur compris entre Banias et les abords de Tripoli.

Ces faits méritaient d'être signalés. Corroborés par d'autres arguments, ils livrent en effet la clef de l'un des problèmes structuraux les plus importants du Djebel Ansarieh, et aussi du Liban et de la Bekaa.

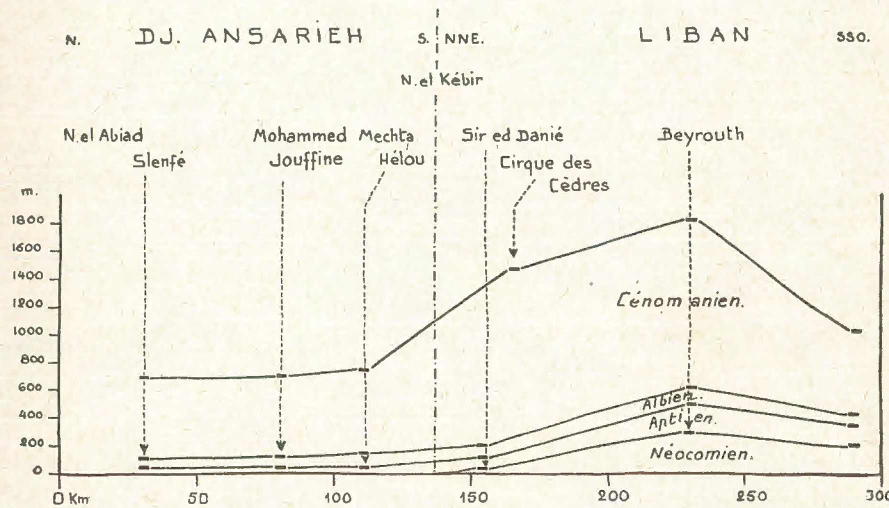

Fig. 1. Variation d'épaisseur du Crétacé au Djebel Ansarieh et au Liban.
La barre des abcisses représente la surface supérieure du Jurassique.

3. *La série stratigraphique du Djebel Ansarieh.*

Le résultat le plus immédiat de l'histoire géologique esquissée ci-dessus est de fournir à la géographie la série des matériaux mis en œuvre dans l'architecture du Djebel Ansarieh.

Cette série se caractérise essentiellement par une énorme masse de calcaires jurassiques à la base. Dans l'escarpement de la montagne qui domine la partie Sud du Rhâb, elle montre une épaisseur visible de 1.200 m. sans qu'il soit possible de connaître l'épaisseur réelle puisque la base du Jurassique ne se fait jour nulle part.

Cet empilement est surmonté de 200 à 210 m. de couches plus diversifiées appartenant à l'Aptien et à l'Albien et surtout par une dalle de calcaires massifs d'âge cénomanien, auxquels font suite sur les bordures de la montagne : 100 à 150 m. de craie sénonienne, 100 à 300 m. de calcaires nummulitiques, des marnes vindoboniennes et des argiles plaisanciennes.

Mis à part les derniers termes, les matériaux sont donc très semblables. Le Djebel Ansarieh est essentiellement calcaire et constitué de roches d'une dureté assez uniforme. Le Sénonien introduit bien un horizon plus tendre entre les assises du Cénomanien et celles du Lutétien mais ses affleurements ne sont que locaux. Le grand élément de diversification qui existait au Liban : les couches du Crétacé inférieur (Néocomien, Aptien, Albien), n'est presque plus représenté ici ou ne l'est dans la mesure où il apparaît que par ses horizons les plus résistants.

Cette quasi disparition du Crétacé inférieur amène à souligner un dernier fait qui a eu un grand retentissement dans la structure et dans la morphologie du Djebel Ansarieh, celui de l'amenuisement général des couches quand on passe du Liban au massif qui le prolonge vers le Nord (fig. 1).

Est-ce déjà le cas pour le Jurassique? La question ne peut être tranchée puisqu'au Djebel Ansarieh comme au Liban, seule son épaisseur visible est connue.

Dans le cas du Crétacé, le doute n'est plus permis. Le Néocomien, épais de 300 m. dans le Liban central, n'en a plus que 30 à Sir ed Danié (Liban septentrional) et disparaît complètement au Nord du seuil Homs-Tripoli. L'Aptien passe de même de 190 m. (Liban central) à 60-80 m. (Liban septentrional) pour n'avoir plus que 30 à 40 m. dans le Djebel Ansarieh. L'Albien subit un amenuisement semblable : 100/150 m. au Liban, 170 m. à Mechta Helou (Djebel Ansarieh méridional) où les basaltes interstratifiés exagèrent sa puissance, 75 m. dans le reste du Djebel Ansarieh. Mais c'est surtout le Cénomanien qui offre la diminution d'épaisseur la plus spectaculaire ; alors qu'il mesurait de 1200 à 1300 m. au Cirque des Cèdres en arrière de Tripoli, il n'en a plus que 500 à 600 au delà du Nahr el Kebir.

La sédimentation a donc été infiniment moins active au Djebel Ansarieh qu'au Liban. Si celui-ci revêt une ampleur beaucoup plus grandiose que celui-là, il le doit en partie au fait d'avoir pu disposer d'un tonnage de matériaux très supérieur [1].

Ces préliminaires permettent d'aborder maintenant l'étude de la structure.

§ II. LA STRUCTURE (PLANCHES I, II, III)

L'unité orographique du Djebel Ansarieh ne prête pas à contestation. A l'Ouest, il domine la mer ; à l'Est, le Rhâb, la cuvette d'Acharné, le plateau de Massiaf et le Waar ; au Sud, les plateaux d'Akkar. Au Nord, il s'anastomose plus étroitement au massif du Djebel Akra. Là aussi cependant, la coupure est nettement discernable tout le long de la dépression que suit la route Lattaquié-Alep et qu'occupe dans sa partie inférieure le Nahr el Kebir septentrional.

Cette unité en fait n'est pas simplement orographique mais aussi structurale et c'est ce qu'il convient de montrer.

I. Analyse de trois coupes typiques

La description de quelques coupes choisies dans divers secteurs du massif va permettre de s'en faire une première idée et d'en dégager les principaux accidents structuraux dont l'analyse sera reprise après plus longuement.

[1] La moindre importance des plissements galiléen, palestinien et du Negeb s'explique aussi (en partie) par le même phénomène. Au Negeb, le Jurassique qui dépasse 1500 m. à l'Hermon n'en mesure plus que de 200 à 450, le Crétacé inférieur est réduit à 250 m., le Cénomanien-Turonien à 300-450 m. ; la craie sénonienne à 100-300 m. Voir : **20**.

Coupe N° 4. — Cette coupe passe par le Djebel Ansarieh septentrional.

A l'Ouest, apparaît le synclinal miocène qui borde la montagne du S.-O. au N.-E. Très vite, les couches nummulitiques, sénoniennes et cénomaniennes en surgissent avec un pendage assez fort.

La montée de ces assises se ralentit bientôt grâce à une pliure [1] et ce n'est plus que très doucement que celles-ci continuent ensuite à s'élever vers l'Est jusqu'au moment où une contre-pliure les redresse assez brusquement aux approches de l'anticlinal jurassique.

Cet anticlinal revêt une allure assez aiguë et fait montre d'une symétrie à peu près parfaite. Son contact avec les couches crétacées est invisible du côté du Rhâb ; du côté Ouest, il montre un écrasement quasi complet des couches aptiennes et albiennes au point que Jurassique et Cénomanien sont presque au contact.

D'une manière générale, cette coupe rappelle celle du Liban méridional ou de l'Anti-Liban septentrional [2]. Elle révèle la même suite d'accidents structuraux majeurs : montée brusque des strates, pliure, montée plus lente formant plateau, contre-pliure, anticlinal aigu, et aussi fracture sur laquelle on reviendra.

Coupe N° 11. — Cette coupe se situe dans le Djebel Ansarieh central.

Elle rappelle la précédente mais avec des variantes qu'il importe de souligner.

Le rebord de la montagne, caché plus au Nord par les sédiments néogènes, est visible ici. Le Cénomanien est d'abord à peu près subhorizontal puis se redresse au delà d'une contre-pliure. L'ascension des couches se poursuit beaucoup plus longuement que dans le Djebel Ansarieh septentrional et ce n'est que vers 900-1000 m. qu'intervient une pliure qui diminue son pendage.

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[1] On appelle pliure un pli en genou dont la convexité est tournée vers le ciel, contre-pliure un pli semblable mais de sens inverse. Pliure et contre-pliure marquent des changements de pendage qui peuvent se faire parfois de manière très brusque.

[2] 2 : Planches I, II, III.

Celui-ci continue cependant à s'élever lentement jusqu'au moment où au passage de la crête orographique, il esquisse une descente également lente.

Cette retombée se précipite toutefois dans la partie basse du flanc oriental de la voûte ainsi formée. Au pied de celui-ci, un contact anormal rapproche Jurassique et Cénomanien dont les strates sont inclinées de façon semblable.

Pris dans toute sa largeur, le Djebel Ansarieh se présente donc comme une large voûte surbaissée au profil en anse de panier. C'est, au moins dans ses grandes lignes, un style équivalent de celui du Liban septentrional et du massif judéen.

Coupe N° 15. — Cette coupe qui traverse le Djebel Ansarieh méridional rappelle la coupe N° 4.

Les couches se dégagent rapidement de la plaine côtière, se recourbent bientôt, effectuent une lente et très longue montée vers l'Est, puis se redressent à nouveau pour laisser apparaître un anticlinal jurassique aux flancs symétriques.

Au delà d'une fracture, bien soulignée dans la topographie par de longs talwegs rectilignes, les strates dans la mesure où elles sont observables sous le manteau basaltique qui les recouvre, plongent vers l'Est et sont d'âge de plus en plus récent au fur et à mesure qu'on progresse dans cette direction.

L'architecture du Djebel Ansarieh méridional est donc semblable à celle du Djebel Ansarieh septentrional quoiqu'elle en représente en quelque sorte un modèle réduit, sinon en largeur — la sienne étant plus grande —, au moins en hauteur.

Ces trois coupes en faisant connaître les principaux accidents structuraux du massif permettent de les suivre maintenant dans le sens longitudinal et de les caractériser de manière plus précise.

II. Le Djebel Ansarieh septentrional

Les différents éléments à examiner sont les suivants : la pliure occidentale, le plateau intérieur, la contre-pliure, l'anticlinal, la fracture orientale.

1. *La pliure occidentale.*

Assez nette sur la coupe N° 4 où elle a un tracé S.-N., elle change assez brusquement de direction à hauteur du village de Talla (cote 523) où elle s'oriente vers le N.-E.

Au-dessous de cette dernière cote, elle cède localement la place à une faille dont le rejet atteint 100 m. environ et qui a provoqué la formation des asphaltes de Kfarié. Cette faille n'est pas très longue : 1 à 1 km. 5. Dès le ravin du Nahr el Koum, la pliure reparaît et la plongée des couches cénomaniennes, horizontales sous le village de Koum, est très visible sur les flancs de la gorge.

Elle se suit difficilement vers le Nord-Est où elle est en général très peu marquée (Coupes 3 et 2) mais discernable quand même de temps à autre. Entre l'Ouadi Semmeta et l'Ouadi ed Dib, — soit sur 2 km. à peu près —, elle fait place à nouveau à une faille (Rejet : 200 m.) comme c'était déjà le cas à Talla.

De l'Ouadi ed Dib à la faille d'Innzik [1], la pliure manque de netteté.

Ne provoquant souvent qu'un faible changement dans le pendage des couches, la pliure bordière existe bien cependant au N.-E. du Djebel Ansarieh où elle se transforme parfois en faille sur de très courts secteurs. Au Sud de la coupe N° 4, elle est beaucoup plus nette.

Les grands ravins qui sabrent ici la montagne de place en place rendent son observation facile. Partout la surface structurale du Cénomanien est nettement visible, elle constitue en effet la limite supérieure des gorges et supporte un large replat déblayé dans la craie sénonienne. Cette surface descend lentement d'Est en Ouest pour plonger plus ou moins brusquement dans la partie aval des ravins où son pendage est même plus fort que celui de la surface topographique (Coupes 4, 5, 6, 8).

En certains points cependant : à hauteur de Qerdaha (Coupe 7), au Sud du Nahr Aïn Delbé (Coupe 9), la pliure s'estompe jusqu'à disparaître. La montée des couches s'y réalise d'une manière beaucoup plus régulière depuis la plaine côtière jusqu'aux abords de l'anticlinal

[1] Voir *infra*, p. 197.

jurassique. Dans ces deux secteurs, la montagne est plus abordable, son caractère de façade sur l'extérieur est atténué, elle dessine en quelque sorte des golfes dans lesquels la transgression plaisancienne s'est avancée plus aisément et où les argiles de celle-ci sont mieux conservées que partout ailleurs.

2. *Le plateau intérieur.* — Le terme de plateau appliqué à la région qui s'étend depuis la pliure bordière jusqu'à l'anticlinal jurassique n'est pas idéal du point de vue morphologique. Il peut être employé tout de même ici dans un sens structural pour désigner la zone où les couches de la montagne sont sub-horizontales.

Ce plateau est constitué par les assises cénomaniennes, soit qu'elles s'y montrent d'une façon générale (Coupes 7, 9), soit qu'elles soustendent des assises sénoniennes et nummulitiques, non déblayées par l'érosion (Coupes 2, 3, 4, 5, 6, 8).

Son pendage est assez constant du Nord au Sud. Il est faible, beaucoup plus faible que celui de la bordure du massif. Il peut être même parfois pratiquement horizontal (Coupes 6, 8).

Sa largeur n'est pas régulière. Elle varie non pas en raison du tracé de la pliure occidentale qui est rectiligne (sauf dans sa partie septentrionale où elle bifurque vers le N.-E.) mais en fonction de la contre-pliure qui la borde à l'Est. Celle-ci en effet est plus ou moins sinueuse selon l'allure affectée par l'anticlinal jurassique.

Tout à fait au Nord, au fur et à mesure que ce dernier plonge sous le Crétacé et que s'efface la contre-pliure qui le borde, le plateau intérieur tend à s'étendre jusqu'à la crête de la montagne (Coupes 1, 2, 3).

3. *La contre-pliure.*

Comme on vient de le voir, elle est inexistante au Nord (Coupes 1, 2).

A partir du Signal de Barza, l'influence de l'anticlinal jurassique commençant à se faire sentir, elle a tendance à s'esquisser dans le Cénomanien (Coupe 3).

Elle devient très nette quand le Jurassique affleure (Coupe 4). D'une certaine manière, le Cénomanien épouse le mouvement de jaillissement de celui-ci tandis que le Crétacé inférieur plus plastique est comprimé

entre les deux masses calcaires du Jurassique et du Crétacé moyen.

En certain point où l'anticlinal jurassique forme une protubérance arquée vers l'Ouest (Coupe 5), la contre-pliure diminue en intensité [1].

D'une manière générale, ce dernier cas demeure exceptionnel et la contre-pliure reparaît nettement au Sud de la coupe 5, le flanc de l'anticlinal étant ici à nouveau plus raide. Elle est quelquefois observable de façon saisissante comme c'est le cas à Jaoubet Bourghal ou au-dessous de Mnaïzlé.

4. *L'anticlinal jurassique.*

Malgré les apparences, son analyse est beaucoup plus difficile que celle des éléments structuraux dont il vient d'être question.

A. *Du côté occidental,* l'anticlinal ne prête pas à contestation.

Les couches jurassiques, invisibles sous le plateau intérieur (à la différence de ce qui se passe au Liban où les morsures de l'érosion ont été plus profondes), commencent à se faire jour dans les ravins à partir de la contre-pliure ou un peu avant (Pl. 3, B).

De là, elles montent rapidement avec des inclinaisons qui peuvent atteindre une quarantaine de degrés jusqu'à la crête de la montagne. Au Sud, les couches esquissent une voûte qui va s'élargissant en direction du Djebel Ansarieh central (Coupes 5 à 9). Au Nord, l'anticlinal est au contraire plus aigu (Coupe 4). Lorsque le Jurassique disparaît un peu après le Nebi Younès, l'axe de l'anticlinal se poursuit dans le Cénomanien. Le rayon de courbure de celui-ci est cependant beaucoup plus grand que celui du Jurassique; on devine qu'entre Jurassique et Cénomanien le Crétacé inférieur a joué le rôle de « matelas amortisseur » et a mal transmis les poussées venues d'en bas [2] (Coupes 3, 2, 1).

En même temps, la voûte cénomanienne ainsi formée se faille selon son axe longitudinal. Cette cassure est très visible au-dessous du signal de Barza (1147 m.), le dernier sommet important de la montagne

[1] Cette avancée semi-circulaire du Sud de Slenfé est très visible dans le paysage où elle a influencé fortement la morphologie. Voir *infra*, p. 236.

[2] Au sujet du rôle joué par le Crétacé inférieur dans la structure, voir *infra*, p. 245.

(Coupe 2). Elle provoque un abaissement du compartiment occidental par rapport au compartiment oriental. Le rejet atteint dans les 300 m. et diminue rapidement au fur et à mesure que le Djebel Qastoun gagne en altitude et rattrape le niveau du bloc oriental, ce qui se trouve réalisé à hauteur du village d'Aarafite. Vers le Nord, l'escarpement du bloc oriental continue et se transforme en une très belle pliure qui fait plonger les couches du sommet de la montagne jusqu'au fond de la vallée.

Quelle est la signification de cette faille? Il est difficile de le préciser. Sans doute est-elle en rapport avec une esquisse de subsidence du couloir du Nahr el Kébir, esquisse que manifestent aussi très localement les failles qui relayent localement la pliure bordière [1].

Tout à fait au Nord, la voûte cénomanienne plonge sous le Sénonien puis le Nummulitique. Cette plongée est accélérée au N.-O., — bien légèrement —, par la pliure bordière et au N.-E. par la faille d'Innzik qui recoupe obliquement l'extrémité du massif selon une direction N.-E.-S.-O. (Rejet 200 m. environ) (Coupe 1).

B. Du côté oriental, le flanc de l'anticlinal demande à être examiné avec le plus grand soin car de cet examen dépend la conception qu'on doit se faire non seulement de la structure du Djebel Ansarieh mais aussi de celle du Rhâb.

On le poursuivra du Nord au Sud :

— A l'Ouest de Djisr ech Chogour, le Djebel Ansarieh dresse une façade abrupte au-dessous de la côte 509, les couches descendent toutes vers l'Ouest et donnent à penser que cet abrupt est un escarpement de faille (Coupe 1).

L'observation du bas du versant prouve qu'il n'en est rien et que la réalité est moins simple (ou plus simple). Dans le ravin que contourne la grande route de Lattaquié à Alep (à 800 m. au Sud de Beit Mohammed Sejri qui se trouve à la pointe de la grande épingle à cheveu de cette route), on voit très nettement les couches passer avec une extrême brusquerie d'une inclinaison lente vers l'Ouest à un plongement vers

[1] Voir *supra*, p. 194.

l'Est qui avoisine la verticale et qui fait passer les couches nummulitiques sous les assises plus tendres du Néogène. Il y a donc une pliure indubitable qui se suit tant vers le Nord que vers le Sud (Pl. 1, A; 2, A).

Dans cette dernière direction, le Sénonien puis le Cénomanien affleurent sur le flanc de la montagne.

— Entre Ichtébrak où aboutit la faille d'Innzik et Cheikh Sindiane, celui-ci est barré de corniches et rappelle le versant de la côte 509. Ces corniches cependant ne sont plus des crêts comme dans le cas précédent mais correspondent à la tranche de couches qui sont déjà en légère pente vers l'Est. Dans l'ensemble, on ne voit pas de plongée plus rapide au bas du versant si ce n'est de part et d'autre de l'Ouadi ed Douair au-dessous du village de Hallouz, de même qu'un peu au Nord de Rhani (quoiqu'en ce point l'observation soit plus douteuse).

— A Sirmaniyé (2,5 à 3 km. au Sud de Cheikh Sindiane), les faits ont une grande netteté et sont particulièrement probants. Les couches subhorizontales à l'Est du Signal de Barza descendent lentement ensuite à partir du village de Merrané (pendage de 15° environ). A hauteur de la côte 440 (c'est-à-dire de Sirmaniyé), elles plongent brusquement, leur pendage atteignant presque la verticale. La coupure de l'Ouadi Sirmaniyé rend le phénomène très visible à hauteur du village du même nom. Au pied du versant, du Nummulitique a été découvert récemment [1] il est en pente de 50° vers le Rhâb. Ces phénomènes se suivent au Nord jusqu'à Cheikh Sindiane mais ils y sont moins nets parce que le bas du versant est difficilement observable et que l'érosion a déjà détruit la pliure en grande partie.

— De Aïn Rihanié à Kharab el Khitazo, le Jurassique affleure. L'observation devient beaucoup plus difficile car les plans de stratification s'y laissent bien mal voir le plus souvent. Le versant de la montagne se termine à partir de 400-500 m. d'altitude par un escarpement où aucune pliure ne se reconnaît plus, notamment à Qalaat-Bourzey.

— De Kharab el Khitazo au moulin de Freïké (Coupe 4), la descente des couches sur le flanc du versant s'observe en de nombreux points,

(1) 30.

son allure est régulière et se fait sans pliure; le caractère anticlinal du Djebel Ansarieh est ici tout à fait certain (Pl. 1, B).

— Après le moulin de Freïké, le versant oriental du Djebel Ansarieh change complètement d'allure. La ligne de contact avec la plaine s'incurve vers l'Ouest et ceci au moment même où l'anticlinal jurassique tend à s'élargir vers le Sud. La crête qui coïncidait jusqu'ici avec l'axe même de l'anticlinal décroche légèrement par rapport à lui à partir de la côte 1441 (1 km. au Sud du Signal de Rouadi), elle mord ainsi déjà sur le versant occidental de l'anticlinal et commence à former crêt, au moins dans la partie supérieure du versant oriental. L'axe anticlinal se trouve donc reporté sur ce versant, il doit passer à peu près à Nobol el Faouqa où effectivement des pendages horizontaux sont observables (Coupe 5) (Pl. 2, B).

En même temps, l'escarpement oriental se rétrécissant par suite de l'incurvation vers l'Ouest de son contact avec la plaine, l'axe anticlinal finit par aboutir au pied même du versant.

— D'En Naour à Ech Chahta (soit sur 21 km. du Nord au Sud) (Coupes 6 à 9), le Djebel Ansarieh présente une façade très haute et très étroite et par conséquent extrêmement escarpée. Certaines couches plus dures et mises en relief permettent de s'apercevoir que tous les pendages sont en direction de l'Ouest. L'axe anticlinal qui atteint la plaine vers En Naour doit suivre désormais le pied de l'escarpement ou même se trouver sous le remblaiement de la dépression du Rhâb.

— Dans le Sud, le contact de la montagne et de la plaine s'incurve à nouveau légèrement mais cette fois-ci vers le S.-E.; au village d'ech Chahta, il tourne carrément plein Est. L'on atteint ici la limite du Djebel Ansarieh septentrional.

Des observations précédentes, il résulte que dans sa partie Nord, ce secteur du Djebel Ansarieh est bien dû à un anticlinal. Aux pendages, partout et facilement reconnaissables du flanc occidental, correspondent sur le flanc oriental suffisamment d'observations pour pouvoir affirmer que les couches redescendent bien de la crête vers le Rhâb. Cette descente se fait d'ailleurs de manière diverse. Dans les assises nummulitiques et cénomaniennes, elle s'opère d'abord de façon lente avec tendance à se précipiter dans le bas du versant. En de nombreux points,

une pliure très nette est observable, elle fait passer les couches d'une inclinaison de 20° environ à des pendages de 40-50° et plus. L'absence de cette pliure en de nombreux autres points s'explique facilement par des arguments d'évolution morphologique. Située très bas dans le versant de la montagne, c'est-à-dire à une faible distance du niveau de base, elle a sauté sous l'effet de l'érosion [1]. Il faut moins s'étonner de ne pas la retrouver parfois que de pouvoir l'observer encore si souvent.

Dans le Jurassique, l'anticlinal est plus régulier et affecte au moins au début l'aspect d'un V renversé; par la suite, il a tendance à se transformer en voûte. Le fait capital dependant réside dans la constatation qu'à partir d'En Naour, tout son flanc oriental disparaît. Cette disparition ne peut s'expliquer que par l'existence d'une fracture.

5. *La fracture occidentale du Rhâb* [2].

Cette fracture mérite d'être examinée de près. A la différence de ce qui vient d'être fait pour le Djebel Ansarieh, on mènera sa description du Sud au Nord.

— Sur les 21 km. qui vont d'ech Chahta à en Naour, le contact de la montagne avec la dépression du Rhâb montre d'une manière évidente qu'une énorme fracture s'est produite dans ce secteur. Toutes les assises jurassiques du versant descendent vers l'Ouest, l'axe anticlinal qu'on suivait depuis la pointe Nord du Djebel Ansarieh disparaît sous la plaine et le flanc oriental lorsqu'il est visible n'y montre aucune pliure brusque qui puisse laisser supposer que celle-ci existe toujours sous les alluvions de la dépression du Rhâb [3]. Quoique les montagnes du Proche-Orient fournissent des phénomènes inattendus dans ce do-

[1] Sur l'évolution morphologique des pliures, voir : **2**, p. 60-61.

[2] Il est préférable de dénommer ~~cet~~ accident : fracture occidentale du Rhab plutôt que fracture orientale du Djebel Ansarieh, afin d'éviter de la confondre avec la fracture libano-syrienne dont il sera question dans la suite et dont elle est nettement distincte.

[3] Rien ne permet donc de supposer qu'on se trouve là en présence du dernier stade d'évolution d'une pliure. Voir : **2**, p. 60 et figure 12, schéma IV.

maine, cette hypothèse est définitivement éliminée par la constatation qu'au Sud d'ech Chahta, le flanc oriental réapparaît brusquement dans toute sa largeur au delà d'un contact O.-E. de la plaine et de la montagne et surtout au delà de la faille transversale de Fakro [1]. Non seulement ce flanc oriental se montre là à nouveau mais il y atteint une largeur qu'il n'avait jamais eue auparavant.

Le rejet de cette fracture est considérable. La crête du Djebel Ansarieh est en effet dans ce secteur entre 1300 et 1500 m., elle correspond à peu près aux assises supérieures du Jurassique alors que celles-ci à l'Est de la fracture dont l'altitude est de 170 m. sont à une profondeur inconnue. Le rejet visible et certain est donc de 1130-1330 m. Le rejet réel doit être beaucoup plus grand car même si on attribue aux cycles d'érosion du Tertiaire une grande activité de dénudation, ils n'ont certainement pas éliminé toutes les assises crétacées et tertiaires qui recouvraient le Jurassique et qui doivent par conséquent subsister au-dessus de lui, cachées par les alluvions du Rhâb. Le rejet réel doit donc atteindre un ordre de grandeur voisin de 1500-1750 m., peut-être même de 2000 m. au cas où le remblaiement alluvial serait très important.

Cette fracture est incontestablement une des plus grandioses du Proche-Orient.

— Au Sud d'ech Chahta, elle disparaît très rapidement du fait que le flanc oriental du Djebel Ansarieh surgit de sous les alluvions du Rhâb et retrouve toute son ampleur après la faille de Fakro. La fracture pénètre donc bien dans la montagne où elle est jalonnée par les points suivants : Ouadi ez Zaouaïyi, Mazar ech Cheikh Ali, deux grandes dolines dont l'une cotée 339 m., hameau de Mechta Khadra, mais elle s'arrête au pied de la faille de Fakro où les deux blocs précédemment dénivelés l'un par rapport à l'autre se retrouvent à la même hauteur.

— Au Nord d'En Naour et surtout de Nobol, elle est plus difficile à mettre en évidence. En rigueur de terme et dans l'état actuel des

[1] Voir *infra*, p. 202, 205.

connaissances stratigraphiques, elle pourrait même presque être niée [1].

Cela ne serait toutefois guère vraisemblable pour les raisons suivantes.

Il est difficile d'admettre en effet qu'une faille dont le rejet atteint quelque 1500 m. s'éclipse soudainement sans que rien dans la structure ou le relief ne rende compte de cet arrêt instantané [2].

L'absence quasi complète d'affleurements du Cénomanien au pied de l'anticlinal jurassique, de Sénomien et de Nummulitique à la base de la voûte cénomanienne qui le prolonge au Nord, s'explique malaisément si aucune faille n'existe entre en Naour et Ichtébrak (Coupes 4, 3). Et cela d'autant plus que les assises crétacées et tertiaires esquissent un enveloppement périphérique de l'anticlinal jurassique dans sa partie Nord et que ces couches existent d'une manière certaine au fond du Rhâb.

Enfin, le fait que morphologiquement le contact de la montagne et de la plaine prolonge exactement vers le Nord celui où au Sud la faille est bien attestée, n'a pas de valeur décisive en soi mais doit être pris tout de même en considération.

Un argument plus positif quoique très localisé peut être invoqué. Il renforce ces considérations dont le faisceau établit déjà une probabilité très grande en faveur de la prolongation de la fracture vers le Nord.

C. Voûte a signalé dernièrement [3] un affleurement de calcaire nummulitique à Aïn Mechta Sirmana (Coupe 2). Les couches sont juxtaposées à celles du Cénomanien et ont un pendage de même orientation, c'est-à-dire vers l'Est. Il ne paraît pas vraisemblable, étant donnée la position locale du Cénomanien et du Nummulitique d'expliquer cette juxtaposition (qui serait dans cette hypothèse un recouvrement) par l'ablation du Sénonien à la suite des cycles d'érosion antérieurs [4]. Il est plus normal d'y voir une faille.

[1] C'était le cas aussi en de nombreux points au Liban pour la fracture libano-syrienne.

[2] Ce qui n'est pas le cas au Sud où la faille de Fakro rend bien compte de l'arrêt de la fracture occidentale du Rhâb.

[3] **30**.

[4] C'est le cas au Djebel Zaouiyé. Voir : **9**, p. 79, fig. 38.

Le rejet de celui-ci est difficile à évaluer. Au moins peut-on essayer d'en donner un ordre de grandeur. Si on estime la surface de base du Nummulitique à 100 m. au-dessous de l'affleurement de la faille, à 100 ou 200 m. l'épaisseur du Sénonien, la surface supérieure du Cénomanien se trouverait à 200-300 m. à l'Est de la fracture. A l'Ouest de celle-ci, cette même surface du Cénomanien ne devait pas se trouver à plus de 100 m. (200 m. au maximum) au-dessus du versant actuel; tout montre en effet que le Cénomanien n'a été ici que très peu raboté par l'érosion. Le rejet de la faille est donc de l'ordre de 300-500 m., ces chiffres constituant plutôt un maximum qu'un minimum.

Malgré son incertitude relative, cette estimation a le grand mérite de montrer que le rejet de la faille s'atténue de manière considérable vers le Nord. D'une valeur de 1500-1750 m. dans le Sud, il passe ici, 20 ou 30 km. plus loin, à 300-500 m.

La réapparition du flanc oriental de l'anticlinal à partir d'En Naour, la descente du Djebel Ansarieh vers le Nord, rendent bien compte de ces faits. La fracture ne joue plus qu'un rôle mineur.

— Il ne faut donc pas s'étonner de voir cette faille s'éteindre vers le Nord. A hauteur de Djisr ech Chogour (11 km. au Nord d'Ain Machta Sirmana) (Coupe 1), il n'y a plus d'argument direct qui oblige à admettre son existence, la pliure très vigoureuse qui existe en cet endroit suffit à expliquer la structure. Si l'on peut admettre cependant que la fracture se prolonge, c'est beaucoup plus parce qu'on la voit reprendre localement un peu plus au Nord [1] que pour des faits immédiatement observables. De toutes manières son rejet est très faible, voire nul, quoiqu'il est très loin d'être impossible qu'il n'en a pas toujours été ainsi au cours des âges géologiques antérieurs.

En résumé, la structure du Djebel Ansarieh septentrional est simple, même si les derniers phénomènes sur lesquels on s'est étendu, demandaient à être précisés exactement. Elle reproduit la structure du Liban méridional, à peu de choses près : montée plus ou moins brusque des couches, pliure, plateau ne s'élevant plus que lentement, contre-pliure,

[1] A hauteur de la gorge du Nahr el Abiad. La faille disparait définitivement dans la région située au Nord de celui-ci.

anticlinal jurassique assez aigu, fracture. C'est un pli à grand rayon de courbure d'un style assez particulier et que termine au Nord un plongement périclinal. Sa seule originalité lui vient par rapport au Liban méridional de ce que la fracture occidentale du Rhâb recoupe sa retombée dans sa partie Sud et en fait disparaître une partie sous les alluvions de la dépression.

III. Le Djebel Ansarieh central

Avec le Djebel Ansarieh central, le style structural du massif change de façon très notable comme le commentaire de la Coupe N° 11 l'a déjà montré.

1. *La contre-pliure et la pliure occidentales.*

La contre-pliure occidentale n'est pas toujours directement observable quoiqu'elle puisse l'être en certains cas (Coupe 11). Sa présence se déduit du fait très simple que la mer borderait les pentes de la montagne si celles-ci ne s'atténuaient vers l'Ouest où existe une zone de reliefs plus bas [1].

Elle est parallèle à la côte dans le Djebel Ansarieh central. Juste après le Nahr Sène, elle tourne vers l'E.-N.-E. et va se raccorder avec celle qui longe l'anticlinal jurassique du Djebel Ansarieh septentrional. Ce tracé transversal explique comment le plateau intérieur de celui-ci s'interrompt vers le Sud pour s'y raccorder par des pendages subitement plus forts avec la voûte très large du Djebel Ansarieh central. Du village de Mnaïzlé à la mer, les couches cénomaniennes se redressent partout très brusquement mais rien n'autorise à voir une faille dans cet accident.

Cette ascension rapide des strates se poursuit jusqu'à une altitude variable puis elle se réduit plus ou moins brusquement. Une pliure existe donc parallèlement à la contre pliure précédente. En arrière de Banias

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[1] Au Liban, le même phénomène existe au pied du Djebel Harissa le long de la baie de Jounié.

et de Dahr es Safra (Coupes 10, 11, 12), elle est relativement nette ce qui correspond bien en même temps au relief qui s'élève ici plus nettement qu'ailleurs. Plus au Sud, elle s'estompe au contraire (Coupes 13, 14) et la montée des couches se fait beaucoup plus régulièrement, d'Ouest en Est.

2. *La voûte anticlinale.*

Cette voûte n'est bien développée qu'au Nord où elle marque le brusque élargissement de l'anticlinal jurassique dont on a vu que lui-même s'était déjà légèrement renflé du Nord vers le Sud.

Dans sa partie la plus typique, cette voûte (Coupes 10, 11) a un profil en anse de panier et sa retombée à l'Ouest comme à l'Est s'effectue par pliure et par brusque accélération des pendages.

Vers le Sud, ce profil s'atténue au moins du côté occidental où la montée des couches s'opère de manière de plus en plus progressive. L'anticlinal tend à se réduire petit à petit en largeur et la transition s'amorce ainsi vers le Djebel Ansarieh méridional qui est une réplique du Djebel Ansarieh septentrional. Il faut noter cependant que la transition est ici infiniment plus progressive qu'au Nord.

3. *La fracture libano-syrienne.*

L'existence d'une très grande faille située au pied oriental du Djebel Ansarieh ne fait aucun doute. Partout la base de celui-ci est soulignée par un contact brusque avec la plaine d'Acharné ou par un alignement de talwegs qui aboutit à la Bouqeïa. Ces faits ne sont pas explicables autrement que par une faille qui n'est que la prolongation de la fracture libano-syrienne qui accompagne le bord oriental du Liban depuis la Bouqeïa jusqu'au coude du Litani [1].

Les caractéristiques de cette faille demandent cependant à être précisées avec soin :

— Du village de Nahr el Bared au hameau d'Aïn ej Journ (Coupe 10), les faits sont difficilement observables car seules des alluvions sont

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[1] Voir : **2**, p. 62-64, 77-78, 105-106, et Pl. I.

visibles à l'Est de la faille [1]. Le rejet doit être notable puisque le Cénomanien est entièrement caché sous le remblaiement de la cuvette d'Acharné.

— A partir du hameau d'Aïn ej Journ, le Cénomanien émerge et forme parallèlement à la fracture une ligne de collines. Son pendage est assez fort (30-40°), semblable à celui du Jurassique du Djebel Ansarieh et de même orientation que lui. La surface supérieure du Jurassique affleure à son tour à l'Est de la faille, un peu avant Massiaf. Le rejet est donc faible car tout donne à penser que les couches jurassiques déblayées sur les pentes orientales du Djebel Ansarieh sont peu importantes et que la surface topographique ne se trouve pas très au-dessous de la surface structurale supérieure du Jurassique. Dans ces conditions, le rejet ne peut pas dépasser 500 m. environ, c'est-à-dire l'épaisseur du Cénomanien lorsque sa partie supérieure est au niveau de l'affleurement de la faille. Au fur et à mesure que le Cénomanien prend de l'altitude, le rejet doit diminuer jusqu'à être voisin de zéro de part et d'autre de Massiaf où le Jurassique affleure à l'Est de la faille (Coupes 12, 13). Dans ce secteur, l'exhaussement du Djebel Ansarieh au-dessus du plateau syrien est à peu près nul..

IV. Le Djebel Ansarieh meridional

La structure est caractérisée par un retour à celle du Djebel Ansarieh septentrional quoique les phénomènes soient moins accentués dans le premier cas que dans le second (Pl. 6, A).

— La pliure bordière est très estompée ou se produit si près de la côte et à une altitude si basse que la zone des pendages forts ne se traduit pas dans le relief. Il y a toutefois au moins vraisemblance à admettre qu'elle continue à ceinturer le relief.

[1] C. Voûte (**30**) a signalé des poudingues néogènes le long de cette faille. Nous n'avons eu connaissance de cette découverte qu'après nos recherches dans la région. De nouvelles observations seraient nécessaires pour savoir quels sont leurs rapports exacts avec la fracture.

— Un plateau intermédiaire s'esquisse au point de vue structural et s'élargit vers le Sud au fur et à mesure que la voûte jurassique se rétrécit et que l'anticlinal qui la prolonge s'individualise mieux (Coupes 14, 15, 16, 17). Une double raison explique que les faits ne soient pas plus apparents, la première est que les déformations structurales sont minimes comparativement à celles du Djebel Ansarieh septentrional, la seconde découle de ce que la morphologie est ici beaucoup plus indépendante de la structure que partout ailleurs (Pl. 6, B).

— Quant à la fracture libano-syrienne, elle montre partout un rejet en faveur du Djebel Ansarieh qui ne cesse de grandir vers le Sud.

Lorsque le Jurassique disparaît sur le bord oriental de la faille un peu après Massiaf et que le Cénomanien vient border le Djebel Ansarieh de ses couches de plus en plus récentes au fur et à mesure qu'on s'avance vers le Sud, on se retrouve dans le cas décrit précédemment [1] mais jouant ici en sens inverse. Le rejet peut donc être estimé à 500 m. environ là où il est le plus fort.

Lorsque les énormes paquets de laves du Djebel Helou viennent recouvrir tour à tour le Cénomanien, le rejet doit être encore plus considérable mais devient impossible à chiffrer en l'absence de toute donnée sur la profondeur de la surface supérieure du Jurassique.

V. Le Volcanisme

Cette étude sur la structure du Djebel Ansarieh ne peut négliger d'accorder une place spéciale aux phénomènes volcaniques qui s'y sont déroulés. Leurs traces sont partout dans le Djebel Ansarieh méridional : Djebel Helou, plateau de l'Akkar, crêtes coiffées de basalte qui se retrouvent non seulement dans le Sud mais encore jusqu'aux environs de Banias. Ces basaltes sont à toutes les altitudes ; ils recouvrent le sommet de la montagne et se retrouvent au niveau de la mer, leur surface de base a une inclinaison semblable à celle des couches qui les supportent mais moins forte qu'elle cependant. Dans la région de Tartous comme dans celle des plissements pré-libanais, ils s'indentent dans

[1] Voir *supra*, p. 206.

les dépôts marins du Plaisancien et se trouvent ainsi datés. La seule vue du paysage suffisait d'ailleurs à montrer qu'ils constituent les restes, d'une immense nappe, autrefois continue et déformée par les mouvements orogéniques récents qui ont affecté le Djebel Ansarieh à la fin du Pliocène. Le creusement des vallées est donc postérieur à leur mise en place, les basaltes demeurent sur les crêtes mais n'occupent jamais le fond des talwegs sinon à proximité immédiate de la mer (Pl. 6, A).

Devant un phénomène d'une telle ampleur, la première réaction est de chercher les appareils volcaniques d'où a pu jaillir une telle quantité de laves. L'enquête s'avère décevante : aucun volcan, ou vestige de volcan n'apparaît nulle part.

Dans ces conditions, la question se pose plus aiguë que jamais de savoir d'où proviennent les épanchements basaltiques du Djebel Ansarieh ainsi que la longue traînée de lave qui va jusqu'aux environs d'Alep et dont on devine bien par la seule vue de la carte géologique qu'elle leur est liée.

Une observation met sur la piste de la solution. A 4 km. au Sud de Massiaf, depuis un point situé à 500 m. au Nord du village de Findara jusqu'au village de Chmeissa, une longue crête basaltique orientée N.-S. longe le pied de la montagne et se trouve située sur le tracé exact de la fracture libano-syrienne (Coupe 13). Dans sa partie Nord, les basaltes ont coulé vers le N.-E. jusqu'au village d'el Beïda. L'origine des basaltes du Djebel Ansarieh n'est donc pas volcanique mais fissurale. Les laves sont montées non par les bouches séparées les unes des autres mais par des failles.

La structure du Djebel Helou confirme cette manière de voir. Au Nord, à l'Est et au Sud, il présente des pentes régulières quoique assez raides qui correspondent à une même coulée. Du côté Ouest au contraire, le long des deux vallées qui jalonnent la fracture libano-syrienne, il montre un versant beaucoup plus escarpé et qui surtout recoupe des niveaux de laves et de cendres plus ou moins agglomérées. Les cendres ne peuvent avoir qu'une origine locale, leur émission n'a donc pu s'opérer que par la faille. Par ailleurs, l'épaisseur des produits volcaniques, égale à la hauteur du versant, se monte à 500-600 m., chiffre qui ne tient pas compte de l'épaisseur des laves situées en profondeur de

telle sorte que le total se monte peut-être à un millier de mètres [1]. Un tel amas de laves sur une même verticale est hors de proportion avec l'épaisseur des nappes qui font suite à celles du Djebel Helou. Même en tenant compte de la dénudation post-plaisancienne, une telle variation est inexplicable.

Il est donc normal de considérer que le volcanisme du Djebel Ansarieh est lié à la fracture libano-syrienne et que le Djebel Helou correspond au grand centre d'émission d'où elles ont divergé.

Leur écoulement s'est opéré en effet dans trois directions principales : d'abord vers l'Ouest où elles ont submergé tout le Djebel Ansarieh depuis le Markab au Nord jusqu'aux premières pentes du Liban au Sud, — ensuite vers le S.-E. où elles ont contourné l'Akroum pour entrer dans la Bekaa et s'y étendre jusqu'à Hermel, — enfin vers le N.-N.-E. où elles sont parvenues jusqu'à Alep.

L'importance du volcanisme pliocène est donc considérable. Il joue dans le relief un rôle de première grandeur. La suite montrera aussi qu'il permet de voir beaucoup plus clair dans l'évolution structurale et morphologique du Djebel Ansarieh et aussi du Liban, de la Bekaa et du bassin de Homs.

Cette importance du volcanisme plaisancien ne doit pas cacher cependant une forme mineure du volcanisme qui est celle du volcanisme quaternaire.

Un peu au Sud de Banias, la région du Markab, montre des cendres en abondance qui ne peuvent venir d'un point aussi éloigné que le Djebel Helou et qui sont donc locales. J. Bourcart note même que « les couches de brèches de pouzzolane et de bombes reposent *sur* des sables bleus à *Arca Diluvii Dentalium, sexangulare Corbula,* Cérithes variés, etc... c'est-à-dire sur un faciès littoral du Pliocène ancien. Ces brèches de projection, ajoute-t-il, sont d'ailleurs coupées de bancs de limons rouges et passent à un très grand cordon littoral qui s'étend de Banias au Nahr es Senn. Celui-ci, à cette hauteur, repose *sur* le *ramleh* tyrrhénien et contient des galets de cette formation. Le volcan ne peut donc être que

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[1] Voir *infra*, p. 217-218.

de même âge ou plus récent que le Moustérien. Cet appareil présente ceci de curieux qu'il ne comporte aucune coulée de lave» [1].

De ces faits, l'on peut conclure que le volcanisme a effectivement joué au Quaternaire dans la région du Markab. Les phénomènes ne sont pas cependant encore parfaitement clairs. Des levers que nous avons faits, il résulte que l'ensemble des couches volcaniques de la région sont en position haute, déformées par la dernière période orogénique et entaillées par les vallées. L'apport du Pliocène paraît donc certain, d'autant plus que nous avons retrouvé dans la montagne en arrière du Markab des témoins non encore signalés de la grande nappe basaltique qui établissent la continuité des affleurements du Markab avec le Djebel Helou. Il resterait à préciser dans cette région les rapports exacts des volcanismes pliocène et quaternaire.

Une preuve moins ambiguë de l'existence d'un volcanisme quaternaire se trouve non loin de là. A 4 km. au N.-O. d'Annazé et à 4 km. 5 au N.-E. de Banias, une vallée a servi sur 4 km. 5 de canal d'écoulement à une émission basaltique. La roche est beaucoup plus fraîche que partout ailleurs. A la partie aval, la coulée bifurque de part et d'autre du village de Deir el Bich, et sa branche septentrionale est limitée par la falaise qui borde la terrasse d'abrasion marine de la plaine de Banias et dont le pied est à 50 m. Cette coulée est donc certainement quaternaire puisqu'elle occupe le fond d'une vallée, elle est aussi antérieure au façonnement de la terrasse de 50 m. et de la falaise qui borde celle-ci. Malheureusement il n'est pas possible de dater cette falaise à coup sûr, étant données les déformations orogéniques qui ont affecté cette terrasse [2]. Au moins, peut-on dire quelle n'est pas du Quaternaire récent. Elle serait plus ancienne que les phénomènes décrits par J. Bourcart aux environs du Markab.

Un dernier fait peut être pris en considération, c'est l'existence encore plus au Nord d'un culôt volcanique dans une dépression près du village de Deïrouné (5 km. O.-S.-O. de Qerdaha). Il semble qu'on soit là en présence d'une ancienne bouche volcanique que sa position topo-

[1] 3, p. 220. [2] Voir **21**, **22**, **24**.

graphique amène à placer dans le Quaternaire. Au dire des habitants, d'autres phénomènes analogues existeraient dans la région.

En conclusion, le volcanisme a bien joué au Quaternaire mais son activité à cette époque a été infime par rapport à celle qu'elle avait eue au Pliocène. Il n'est plus lié alors à des failles mais à des appareils volcaniques bien que ceux-ci aient disparu à l'heure actuelle. Ces conclusions rejoignent celles qui ressortaient déjà de l'étude du volcanisme du Rhâb et du Djebel Zaouiyé [1].

VI. Le profil longitudinal du Djebel Ansarieh et l'abaissement du seuil Homs-Tripoli

La description d'une montagne ne peut en rester à l'analyse de sa coupe transversale, le profil longitudinal n'est pas moins significatif. Dans le cas du Djebel Ansarieh, celui-ci se révèle d'un intérêt exceptionnel et livre l'explication de phénomènes capitaux qui ont eu leur retentissement non seulement au Djebel Ansarieh et au Liban mais aussi en Syrie intérieure et dans la Bekaa.

1. *Profil longitudinal du Djebel Ansarieh* (Coupe longitudinale N° 18, planche III).

Il mérite d'être observé selon différents axes, les variations des profils transversaux étant assez considérables selon les différents secteurs de la montagne.

A. *Profil longitudinal de l'axe anticlinal.* — Il commence par une montée qui s'amorce à la coupure du Nahr el Abiad où le Nummulitique surgit de sa couverture miocène. Successivement apparaissent au fur et à mesure que l'on progresse vers le Sud : l'Eocène supérieur, l'Eocène moyen, le Sénonien, le Cénomanien, le Jurassique enfin au Nebi Younès.

Par la suite, seul le Jurassique est visible sur l'axe de l'anticlinal, toutes les autres couches ayant été déblayées. Bien qu'il ne soit pas possible par conséquent de suivre une même surface structurale (celle du Jurassique-Crétacé en l'occurrence), l'allure topographique de la

[1] **25**, **26**.

crête qui coïncide avec l'axe anticlinal permet toutefois de donner une idée du profil longitudinal de la structure elle-même. Nulle part en effet le déblaiement des couches sur le sommet de la montagne n'a été très important. Par ailleurs on verra que la surface polycyclique qui s'étend pratiquement jusqu'aux sommets est toujours affectée de déformations de même sens que celles des couches, ses pentes reproduisent fidèlement les pendages des strates quoiqu'avec une inclinaison moins forte par définition. Il en résulte que l'on peut faire confiance au profil topographique de la crête pour suivre les variations longitudinales de la structure.

Dans le Djebel Ansarieh septentrional, le profil est sensiblement horizontal, très élevé du Nebi Younès au Signal de Rouadi (1500-1600 m.) (Coupe 4), un peu plus bas par la suite (Coupes 5, 6, 7, 8, 9). Cette diminution d'altitude est imputable surtout au fait que la crête de la montagne ne coïncide plus ici exactement avec le sommet de l'anticlinal par suite de l'effondrement du Rhâb et de l'érosion remontante.

Le Djebel Ansarieh septentrional est donc la partie la plus haute du massif non seulement du point de vue morphologique mais aussi sous l'angle structural.

Dans le Djebel Ansarieh central en effet, le profil descend du Nord au Sud de 1500-1400 m. à 1000 m. selon une pente assez régulière (Coupes 10, 11, 12, 13, 14).

Dans le Djebel Ansarieh méridional, la retombée s'accélère; elle passe de 1000 m. au Nord à 750 m. à hauteur du Djebel Helou, le Cénomanien se faisant jour à nouveau à cette altitude; puis elle se précipite puisqu'à 18 km. de là, le Jurassique est à des centaines de mètres sous le manteau basaltique des plateaux de l'Akkar (300 à 400 m. d'altitude).

B. *Profil longitudinal du versant occidental.* — Il ne reproduit pas celui de la crête et par là rappelle des phénomènes analogues observés au Liban.

Dans le Djebel Ansarieh septentrional, la surface supérieure du Jurassique est très bas, au niveau de la mer ou même au-dessous. La contre-pliure transversale qui va de Mnaïzlé au Nahr Sène amène chez lui un brusque redressement (Coupes 9, 10).

Dans le Djebel Ansarieh central, elle se tient donc très haut : vers 1000-1100 m. (Coupes 10, 11) mais ne tarde pas toutefois à descendre vers le Sud, l'inclinaison se faisant de manière lente et continue jusqu'aux plateaux d'Akkar : 750 m. (Coupe 12), 500-250 m. (Coupe 13), niveau de la mer (Coupes 14, 15), au-dessous de celui-ci (Coupe 16), très grande profondeur (Coupe 17).

C. *Profil longitudinal du socle en bordure de la fracture libano-syrienne.*

Il ne sera pas question ici de la zone Nord, occupée par le Rhâb Elle pose trop de problèmes qui lui sont propres pour pouvoir être déjà abordée. On s'attachera seulement au secteur où le Djebel Ansarieh est juxtaposé directement au socle si bien représenté ici par la cuvette d'Acharné, le plateau de Massiaf et le Djebel Helou.

Des environs du Nahr el Bared où le socle et sa couverture sont enfouis sous les alluvions, le socle monte en direction de Massiaf (Coupes 10, 11), le Cénomanien, le Crétacé inférieur et le Jurassique affleurant successivement. Celui-ci apparait de part et d'autre de Massiaf où il marque par conséquent son point d'élévation le plus grand (Coupes 12, 13). Il redescend après vers le Sud comme le montre son enfouissement sous les laves du Djebel Helou (Coupe 15) au-dessous desquelles il doit se trouver à une grande profondeur.

En résumé, l'allure longitudinale du Djebel Ansarieh se caractérise par une culmination dans sa partie septentrionale pour la crête, à la limite Sud de celle-ci pour le versant occidental. La retombée vers le Nord en direction du couloir du Nahr el Kebir se fait assez rapidement. Au Sud au contraire, tout l'édifice montagneux poursuit une descente généralisée vers les plateaux d'Akkar aux approches desquels la plongée se précipite. Quant au socle syrien, son profil est à peu près le même, sa culmination transversale étant seulement un peu plus méridionale.

Le grand fait structural que révèle le profil longitudinal est donc l'existence du seuil Homs-Tripoli.

Du côté libanais, on a déjà dit antérieurement [1] qu'il s'opérait avec

[1] **2**, p. 68-69 et pl. III, Coupe XX.

une grande rapidité : la surface de base du Cénomanien qui est à 2000 m. au Qornet Arouba, n'est plus, 25 km. plus loin, qu'au niveau de la mer ou même au-dessous dans les plateaux d'Akkar. La flèche de l'ensellement a donc un minimum de 2000 m.

Du côté du Djebel Ansarieh, cette même surface de base cénomanienne est à 750 m. à hauteur du Djebel Helou, vers 1500 m. dans la partie centrale de la montagne. La flèche de l'ensellement est moins grande mais dépasse cependant 1500 m., ce dénivelé s'opérant ici sur une soixantaine de km. de distance.

Tel est le grand fait structural dont il faut essayer maintenant de retracer la genèse et l'évolution comme les incidences sur la morphologie générale de la région.

2. *Genèse du seuil Homs-Tripoli.* — Deux catégories de phénomènes aident à reconstituer l'évolution du seuil Homs-Tripoli : l'observation des anciens rivages atteints par les transgressions du Tertiaire, — les déformations de la surface de base de la nappe basaltique pliocène.

A. *Position des rivages des mers tertiaires et conséquences qui en découlent* (Figure 4).

La brève esquisse géologique, donnée plus haut, a déjà montré que les limites atteintes par les transgressions nummulitique, vindobonienne et plaisancienne ne se succédaient pas partout au Djebel Ansarieh dans l'ordre habituel. Sur la côte syro-libano-palestinienne, les anciens rivages sont d'ordinaire d'autant plus reportés vers l'Ouest qu'ils sont plus récents, les transgressions n'ayant cessé de diminuer d'amplitude. Le long du Djebel Ansarieh central et méridional comme le long du Liban septentrional, cet échelonnement n'est pas respecté et par là pose un problème. Il reste donc à en tirer les enseignements.

Le rivage nummulitique se trouvait très au large de la côte actuelle. Aucun affleurement d'âge lutétien n'est en effet connu depuis le Markab jusqu'à la Galilée libanaise, autant dire tout le long de la vaste incurvation que la côte présente entre ces deux points et dont la baie d'Akkar n'est que l'endroit le plus enfoncé. Cette constatation ne s'explique que si la chaîne Ansarieh-Liban dont on a déjà dit qu'elle ne constituait qu'un même anticlinal [1] était à cette époque beaucoup plus large et par conséquent beaucoup plus haute qu'elle ne l'est à l'heure actuelle dans ce secteur. Elle formait alors une large protubérance vers l'Ouest et il n'est pas impossible que l'emplacement du seuil Homs-Tripoli ait correspondu à ce moment à la culmination de tout l'édifice.

Le rivage vindobonien montre déjà l'esquisse d'une grave perturbation. Il quitte la côte un peu plus au Nord que le rivage nummulitique, il est donc d'abord en position extérieure par rapport à lui. Par contre au Liban, le Vindobonien affleure largement en arrière de Tripoli depuis les plateaux d'Akkar jusqu'à Ras Chekka, il transgresse par conséquent largement sur la limite atteinte par la mer nummulitique dont les dépôts sont inconnus dans ce secteur et vient border le pied même de la montagne libanaise. Une large baie s'était donc ouverte durant l'Oligocène et le Burdigalien dans l'édifice montagneux antérieur, un rétrécissement considérable de celui-ci s'était opéré qui n'avait pu se produire sans une perte d'altitude équivalente. Ainsi s'ébauche un premier seuil entre le Djebel Ansarieh et le Liban au point où celui-ci a présentement sa culmination maximum qui est donc le résultat des périodes orogéniques postérieures.

C'est sans doute cet ensellement ancien, actuellement disparu, qui a déterminé la fixation du cours de la Qadisha alors qu'actuellement cette rivière se trouve correspondre à une culmination structurale du massif libanais. Son tracé serait donc une survivance de l'époque pontienne.

Le rivage plaisancien est très significatif et donne la clef de la structure actuelle. Il borde le Djebel Ansarieh septentrional, ne s'en écarte que légèrement à hauteur de Banias car on le retrouve peu au Sud de cette localité et bien avant Tartous ; il occupe tout le fond de la plaine d'Akkar, ne s'arrêtant qu'au pied du Djebel Ansarieh et du Liban, un peu au Nord de Tripoli, il déborde sur le rivage vindobonien mais à hauteur de cette ville, prend une position en retrait par rapport à lui. Il correspond donc à une baie très large, de même dessin que le littoral actuel mais beaucoup plus incurvé que lui. Il dénote un relief très semblable à celui de l'heure présente mais encore plus bas puisque la

[1] **19**, p. 282-283 et fig. 8 ; **2**. p. 101 ; **27**.

mer plaisancienne a atteint une côte voisine de 200-250 m. d'altitude. Le seuil Homs-Tripoli existait donc quand cette mer a transgressé. Il est donc à dater du Pontien. C'est à cette époque que la première ébauche d'un ensellement esquissé à l'Oligocène et au Burdigalien à hauteur de la Koura (arrière pays de Tripoli) s'est reportée plus au Nord sur l'emplacement que le seuil occupe aujourd'hui.

Une autre série de faits permet de serrer le problème de plus près et de poursuivre l'évolution de ce seuil.

B. *Les déformations de la surface de base de la nappe basaltique* (figure 4 et planche IV).

La surface sur laquelle se sont répandus les basaltes pliocènes est facile à dater car ils recouvrent les couches arasées du Jurassique, du Crétacé, du Nummulitique, et dans l'intérieur du pays comme sur le bord du Liban, des poudingues néogènes. Elle est donc pontienne. La grande extension de la nappe volcanique de même que son morcellement qui permet d'observer les cotes de sa surface de base est un excellent moyen pour se rendre compte des déformations subies par la surface pontienne depuis qu'elle a été pénéplanée.

Deux secteurs sont à examiner successivement : celui des massifs côtiers situés à l'Ouest de la fracture libano-syrienne, celui du socle qui s'étend à l'Est de cette faille.

Du côté des massifs côtiers, elle descend vers la mer; ses déformations transversales s'expliquent facilement par le relief antérieur au Pontien et dérivant du plissement préexistant, relief que les dernières orogénèses n'ont fait que revigorer [1]. Son relèvement sur le bord du Liban, à contre pente par conséquent du sens où les basaltes ont coulé, n'offre pas non plus de difficultés. Il est dû au dernier plissement post-plaisancien de ce massif [2].

Du côté du socle syrien au contraire, les déformations de la surface pontienne ne peuvent plus être attribuées seulement à des plissements

[1] Le Djebel Ansarieh et le Liban se sont toujours plissés en effet selon le même axe longitudinal. Voir supra, p. 188 et **2**, p. 39-40.

[2] **2**, p. 66.

transversaux. Elles requièrent pour être compréhensibles une subsidence longitudinale qui a revêtu une ampleur considérable.

Au-dessous du Djebel Helou, la surface pontienne est en effet enfouie à une profondeur très grande puisque les vallées qui jalonnent la fracture libano-syrienne ne l'atteignent pas, et la Bouqeïa non plus alors que le fond de celle-ci cote un peu moins de 300 m. — Vers le Nord du Djebel Helou, elle reparaît vers 500 m. — Vers le N.-E., elle affleure au fond de la vallée de l'Oronte près de l'usine électrique de Gajar à 330 m.; de là, elle remonte sur les versants de la gorge jusqu'à atteindre le plateau (420 m.) en face de Rastane; 9 km. plus loin et en progressant toujours dans la même direction, elle cote 650 m. à la butte du Djebel Abou Dardé que couronne un chapeau de basalte. Il y a donc un relèvement de 320 m. en 17 km. dans une région qui est déjà assez extérieure du Djebel Helou lui-même. — Vers le Sud, il en est de même, la boulée basaltique étant entrée dans la Bekaa et ayant cheminé jusqu'à Hermel : la surface pontienne commence à apparaître dans l'angle S.-E. de la Bouqeïa à 280 m. puis s'élève très vite jusqu'à 492 m. au-dessus du Nahr el Kebir. Le long de l'Ouadi Serkhane, sa montée se poursuit au moins jusqu'à 605 m. (hameau de Hite). Un lambeau, situé quelques kilomètres plus loin est à une altitude semblable mais les témoins de Hermel par contre montrent que la surface pontienne se hausse en cet endroit à 700-750 m. Son relèvement est donc de 420-470 m. sur une distance de 35 km. il est d'autant plus fort qu'on est proche du Djebel Helou.

Le plongement de la surface pontienne en direction du Djebel Helou est donc générale et il s'opère non seulement dans le sens transversal mais aussi dans le sens longitudinal. Il prouve que le Djebel Helou a été le centre d'une subsidence extrêmement accusée depuis les émissions basaltiques du Plaisancien car il est bien évident que la nappe basaltique n'a pu se répandre à contre pente de la surface pontienne. D'après ce qu'on peut observer à la périphérie du Djebel Helou, la subsidence a été de 320 m. au N.-E., de 420-470 m. au Sud.

Ces chiffres permettent de se faire une idée de la subsidence du Djebel Helou et de l'épaisseur qu'y ont les laves. Entre le Djebel Abou Dardé (650 m.) et l'usine de Gajar (330 m.) la surface pontienne descend

régulièrement de 320 m. sur 17 km. Si l'on prolonge cette pente en direction du Djebel Helou (il y a 29 km. de Gajar à la verticale de cette montagne), on s'aperçoit qu'en supposant la pente uniforme (alors qu'elle a toute chance d'augmenter comme le montrent bien les cotes relevées de la Bouqeïa à Hermel), celle-ci s'abaisse à nouveau de 545 m. de telle sorte qu'elle doit se trouver sous le Djebel Helou à — 225 m.

L'épaisseur des laves est donc au minimum de 225 + 1000 = 1225 m.

Encore ne s'est-il agi là que de l'abaissement au-dessous de l'horizontale de la surface pontienne alors que celle-ci au moment des éruptions ne pouvait pas ne pas descendre du Djebel Helou vers l'extérieur. La subsidence calculée entre le Djebel Helou et le Djebel Abou Dardé (Djebel Helou-Gajar : 545 m. + Gajar-Djebel Abou Dardé : 320 m.) est donc au minimum de 865 m., en réalité beaucoup plus grande si on tient compte que la subsidence a été maximum au cœur du Djebel Helou et que la surface pontienne était inclinée vers l'extérieur.

Rétabli dans sa position première, le Djebel Helou avec l'énorme masse de ses laves aurait facilement une altitude de 2500 m.

Divers aspects de cet enfoncement peuvent être serrés de plus près si l'on examine les rejets de la fracture libano-syrienne non plus en fonction de la surface de base du Cénomanien mais en fonction de la surface pontienne.

3. *Rapports des massifs côtiers et du socle syrien.*

L'immense socle syrien s'étend, sans qu'aucune faille ne le morcelle, depuis les solitudes du désert jusqu'à la fracture libano-syrienne. A l'Est de celle-ci, tous les éléments de la structure sont solidaires, qu'il s'agisse de la Bekaa, de l'Anti-Liban, du bassin de Homs, du plateau de Massiaf ou du Hamad avec ses plis de couverture. A l'Ouest au contraire, le Liban et le Djebel Ansarieh forment un bloc indépendant.

Dans des études antérieures, nous avons déjà défini les rapports qui existaient entre le Liban et le socle. Le rejet de la fracture qui les sépare, ne dépasse pas 500 m. dans le Liban méridional, 750 m. dans le Liban septentrional. Il s'agit là de valeurs maximum ; la plupart du temps, il est moins fort. Le point le plus significatif à noter est qu'il n'a pas toujours joué en faveur de l'exhaussement du Liban. Si ce cas semble être le cas général, il n'en est pas moins bien prouvé qu'au dessous du Sannin, c'est le bloc du Liban qui a été structuralement dénivelé de 600 m. environ par rapport au socle.

Au Djebel Ansarieh, le bloc côtier est partout exhaussé par rapport à ce socle [1]. A hauteur de la cuvette d'Acharné et du plateau de Massiaf, le rejet n'est pas très considérable (500 m. environ), aux abords même de Massiaf il est à peu près nul [2]. Il s'agit ici du rejet calculé par rapport à la surface supérieure du Jurassique qui totalise tous les mouvements positifs ou négatifs qui ont pu se produire de part et d'autre de la fracture libano-syrienne.

L'ouverture du seuil Homs-Tripoli à partir du Pontien amène à se demander comment la fracture a joué depuis cette époque.

A. *Position réciproque du Liban et du socle.* — Le renversement de pente de la Bekaa septentrionale après le Pontien est certaine [3]. A cette époque, l'inclinaison se faisait du Nord au Sud ce qui a permis aux coulées volcaniques d'y pénétrer. La Bekaa a donc participé à la subsidence du seuil Homs-Tripoli et avec elle les avant-monts libanais qui en marquent le relèvement et notamment le Djebel Akroum qui constitue l'extrême pointe de ceux-ci.

Le Djebel Akroum semble cependant être resté en saillie et avoir canalisé les épanchements volcaniques d'un côté vers la Bekaa, de l'autre vers les plateaux d'Akkar. Dans cette dernière région, les basaltes sont venus s'aligner à son pied le long de la fracture libano-syrienne. Le rejet de cette fracture en faveur de l'Akroum était donc déjà acquis au Pontien. Il a dû rejouer dans le même sens après le Plaisancien sans quoi l'on s'expliquerait difficilement la fraîcheur de l'escarpement de faille et le dénivelé qui existe entre la surface d'érosion qui s'est étendue de part et d'autre de celui-ci.

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(1) On réserve ici le cas du Rhâb dont il sera question dans des publications ultérieures.

(2) Voir *supra,* p. 206, 207.

(3) Voir *supra,* p. 217 et aussi *infra,* p. 256-258.

La conclusion essentielle est qu'au Liban, c'est le bloc côtier qui a subi au Pontien et après le Plaisancien la subsidence la plus prononcée, l'Akroum continuant à dominer l'Akkar.

B. *Position réciproque du Djebel Ansarieh et du socle.* — Cette position est exactement l'inverse de la précédente. Si l'on suit les deux vallées opposées qui jalonnent la fracture libano-syrienne, depuis la Bouqeïa jusqu'au village d'Aïn Halaqim, les basaltes sont continus du côté Est où leur énorme empilement forme le Djebel Helou ; l'on a suffisamment dit que leur surface de base se situait à une grande profondeur pour qu'il soit utile d'y revenir. Du côté Ouest au contraire, les basaltes ne recouvrent plus l'anticlinal jurassique que d'un manteau assez mince et déjà disséqué par l'érosion. La couverture volcanique disparaît au hameau de Btar, c'est-à-dire à peu près au col qui sépare les deux vallées, ce qui revient à dire que la surface pontienne affleure ici (Coupe 16). Elle s'y trouve à 700 m. d'altitude alors qu'elle est de l'autre côté de la vallée à des centaines de mètres plus bas.

Il est donc incontestable que le Djebel Helou a été beaucoup plus abaissé par la subsidence post-plaisancienne que le Djebel Ansarieh. Son sommet domine toujours légèrement celui-ci mais infiniment moins qu'il ne le faisait au Plaisancien quand la nappe basaltique s'est répandue. On ne s'expliquerait d'ailleurs pas autrement comment celle-ci aurait pu atteindre le Markab au N.-O. et le Liban au S.-O.

4. *Conclusions.*

L'histoire du seuil Homs-Tripoli peut donc se résumer ainsi.

A l'origine, le Djebel Ansarieh et le Liban sont en continuité non seulement structurale mais orographique. Au Nummulitique, cette chaîne était très large et très élevée sur l'emplacement actuel du seuil. A l'Oligocène et au Burdigalien s'esquisse un abaissement d'axe qui ne subsistera pas. Au Pontien, le seuil actuel s'ouvre dans toute son ampleur, les massifs côtiers étant beaucoup plus abaissés que le socle syrien.

Au Plaisancien, la mer entre dans le vaste golfe dessiné par ce seuil qui disparaît (ou au moins qui s'estompe fortement) au moment où se déclanche la nouvelle phase orogénique qui porte très haut le Djebel Helou. Des flots de basalte se répandent. Après leur mise en place, la subsidence reprend et ouvre à nouveau le seuil Homs-Tripoli. La Bouqeïa s'effondre.

C'est à cette époque également qu'ont dû jouer la faille transversale de l'ouadi Gehennam et les deux failles obliques de l'Akroum qui précipitent la retombée du Liban et des avant-monts libanais en direction du seuil. La subsidence est maximum au Sud du côté du bloc côtier, au Nord du côté du socle. Enfin les terrasses d'abrasion marine permettent grâce à leur déformation de fixer le terminus ad quem de cette subsidence [1]. En arrière de Tartous, elles sont magnifiquement développées et ne cessent de s'abaisser, à l'exception de la terrasse inférieure, en direction du seuil. Cette constatation est d'autant plus intéressante qu'elle montre que les déformations tant longitudinales que transversales se terminent à la même époque.

§ III. LE FAÇONNEMENT GÉNÉRAL DU MASSIF

(Planches II, III, IV)

Que la structure soit responsable du relief du massif dans ces très grandes lignes, est indiscutable. Partout, les déformations des couches ont décidé des principales unités morphologiques qui le composent. Les commentaires des coupes sur le plan structural n'ont pas besoin d'être repris en détail pour s'en convaincre : la crête orographique correspond à l'anticlinal jurassique, le plateau intérieur du Djebel Ansarieh septentrional comme celui du Djebel Ansarieh méridional à un pendage lent des couches, les contre-pliures et les pliures se traduisent également très directement dans la morphologie, sans parler de la fracture occidentale du Rhâb et de la fracture libano-syrienne qui soulignent le contact de la plaine ou sont jalonnées par de grands talwegs rectilignes. Ce dernier cas excepté, la surface topographique épouse tous les mouvements des strates. Même si par la suite, de nouvelles précisions viennent nuancer cette constatation, il n'en demeure pas

[1] **21, 22, 24.**

moins vrai que le Djebel Ansarieh pris globalement représente un volume dont la délimitation superficielle est causée essentiellement par l'architecture interne des couches qui en forment l'armature.

Comme au Liban, et dans l'Anti-Liban, comme en Palestine et dans la dorsale du Negeb, cette adaptation générale de la morphologie à la structure devait être soulignée. Nulle part ne se rencontrent de grands accidents structuraux qui auraient disparu sans laisser de trace dans le relief présent.

L'œuvre de l'érosion est cependant très loin d'être inexistante. Le premier trait qui frappe l'observateur à ce point de vue est la dissection très poussée du massif par les gorges transversales. Partout la montagne est entaillée de vallées profondes qui sont beaucoup plus proches les unes des autres qu'elles ne le sont au Liban. Dans ce dernier massif, elles sont relativement espacées, donnant naissance à de véritables petits pays intérieurs; au Djebel Ansarieh au contraire, elles sont très proches les unes des autres de telle sorte que les interfluves sont très étroits, voire inexistants; bien souvent les versants des vallées se recoupent entre eux et donnent naissance à des crêtes qui descendent du faîte de la montagne jusqu'à la mer ou au moins jusqu'à proximité de celle-ci. Le Djebel Ansarieh donne une impression de confusion beaucoup plus grande que celle éprouvée au Liban où l'ordonnancement général du relief est clair et même grandiose.

Mais si faisant abstraction des coupures des vallées et comblant par la pensée leurs entailles, on essaye de définir la nouvelle impression que procure l'ensemble du relief, on est frappé alors par sa monotonie. Les formes structurales, — autres que celles très générales dont il a été question plus haut, — sont rares. L'érosion différentielle a encore très peu joué; elle s'est bornée à dégager dans le Djebel Ansarieh un crêt où les calcaires nummulitiques font office de couche dure au-dessus de la craie sénonienne plus tendre, elle a ébauché aussi parfois — mais à peine — des éléments de crêt cénomanien au contact du noyau jurassique et à la faveur du déblaiement des couches aptiennes et albiennes. Les résultats sont maigres dans l'ensemble. L'échelle stratigraphique en est certes responsable pour une grande partie : la quasi disparition du Crétacé inférieur fait que la masse des calcaires cénomaniens vient pratiquement en continuité de celle des calcaires jurassiques et que la ligne de faiblesse de l'Aptien et de l'Albien, si activement exploitée par l'érosion au Liban, n'existe guère ici. Elle n'en est pas seule responsable; même dans le cas du crêt nummulitique relativement bien dégagé apparaît quelque chose de mal venu. Lorsque d'un bon observatoire, on regarde la montagne dans toute sa largeur, il ne figure que comme un cran relativement peu important dans la montée générale du relief vers les sommets.

I. L'hypothèse d'une surface d'érosion primitive.

Petit à petit, l'impression s'impose donc à l'esprit que la morphologie actuelle dérive d'une même surface topographique primitive, tangente à tous les points hauts du relief. Cette surface suit toutes les déformations de la structure qui y marquent des inflexions plus ou moins marquées. Elle ne coïncide pas cependant avec elle car partout on la voit recouper les assises du Néogène, du Nummulitique, du Crétacé et du Jurassique.

A première vue, cette hypothèse parait hardie ou tout au moins indémontrable tant le relief a été disséqué par les torrents et tant ses restes paraissent réduits.

Ce qui se passe dans le Djebel Ansarieh méridional montre pourtant qu'il n'en est rien et que cette surface d'érosion primitive peut être démontrée. C'est même dans ce dernier secteur qu'il a été question pour la première fois en Syrie et au Liban d'une ancienne pénéplaine.

Dès 1937, L. Dubertret écrivait : « Le paysage de la partie méridionale du Massif Alaouite est bien semblable à celui des régions septentrionales, mais il existe des différences sensibles dans les proportions et dans la structure. La montagne s'y étend, depuis la côte jusqu'à la grande faille maîtresse méridienne, sur quarante km. de largeur. Les différences de relief sont moindres : lignes de crêtes et sommets définissent une surface qui, de la plaine d'Akkar, s'élève très doucement et régulièrement vers le N.-N.-E. Les crêtes orientales sont toujours très régulières, mais moins hautes : elles tombent de 1400 m. au Nord (au contact de la moitié septentrionale), à 800 m. au Sud, près

de Mechta Helou. Les couches ont la même direction que la surface définie par les crêtes, mais un pendage un peu plus grand ; de là, l'impression d'une sorte de pénéplaine soulevée faisant affleurer des couches cénomaniennes au Sud et à l'Ouest et des couches jurassiques à l'Est et au N.-E., impression qui devient une certitude lorsqu'on examine de plus près la surface sur laquelle se sont répandues les coulées basaltiques récentes» [1].

Ainsi, dans tout ce secteur, la présence de témoins de l'ancienne nappe basaltique plaisancienne montre jusqu'à l'évidence que, malgré le découpage du relief par les vallées, malgré même le recoupement des versants de celles-ci, les crêtes dont beaucoup portent encore des lambeaux de basalte, définissent bien une ancienne surface d'érosion. Très déformée puisqu'elle monte depuis la mer jusqu'au sommet de la montagne, elle recoupe tour à tour toutes les assises depuis le Nummulitique jusqu'au Jurassique (Pl. 6, A, B).

La pénéplanation du Djebel Ansarieh n'est donc pas seulement une hypothèse séduisante, son existence bien attestée dans tout le secteur méridional (et une bonne partie du secteur central) montre que l'hypothèse rejoint ici la réalité.

Il reste à voir maintenant plus en détail comment elle s'est formée, si des témoins en subsistent dans les autres secteurs de la montagne et quel rôle elle a joué dans le façonnement de celle-ci.

II. Les anciennes surfaces d'érosion.

L'histoire géologique du Djebel Ansarieh a déjà attiré l'attention sur les lacunes qui ont existé dans la sédimentation durant l'Eocène inférieur ; — l'Eocène supérieur, l'Oligocène et le Burdigalien ; — le Pontien, — et enfin l'époque présente. Ces lacunes correspondent à des émersions et par voie de conséquence à des phases orogéniques qui ont donné naissance au massif. Dire cela, c'est dire équivalemment que durant ces périodes, le Djebel Ansarieh a été soumis aux érosions subaériennes qui ont eu quelque chance de laisser des traces dans le relief.

[1] **8**, p. 12. Voir aussi **9**, p. 75-76.

Effectivement chacune de ces périodes a laissé des témoins non ambigus de pénéplanation.

1. *Surface d'érosion post-sénonienne et anté-nummulitique* (S 1).

L. Dubertret a noté depuis longtemps et à plusieurs reprises que : « dans la région des Alaouites et la région d'Antioche, l'Eocène inférieur manque.... et (que) le Crétacé a subi une érosion marquée avant le dépôt de l'Eocène moyen» [1]. Il ajoute qu'« aux Alaouites, le Crétacé supérieur.... est raviné par l'Eocène» [2] et qu'« à Khan el Djoz... sur la route Lattaquié-Alep, à environ 7 km. au Nord de Khoder... l'Eocène bréchique et calcaire transgresse sur un Sénonien réduit à une dizaine de mètres de puissance» [3]. En certains points, cette dénudation a été jusqu'à l'élimination complète de la craie sénonienne : « à l'angle N.-O. du horst, l'Eocène bréchique et calcaire, est mis en contact direct avec le Cénomanien, fait que l'on peut observer un peu au Sud de Haffé, sur les pentes du profond ravin que l'on doit franchir pour se rendre au fameux Kalaat es Sahyoun» [4].

L'existence d'une surface d'érosion post-sénonienne et anté-lutétienne (S 1) est donc bien avérée au Djebel Ansarieh, au moins dans son secteur septentrional. Cette surface, étant la plus ancienne de toutes, est par suite la plus déformée puisqu'elle a subi tous les mouvements orogéniques du Tertiaire et du Quaternaire. Soumise également à toutes les phases d'érosion qui ont accompagné ceux-ci, elle a été recoupée par les aplanissements postérieurs. Elle n'a donc pas laissé de traces dans le relief, sauf peut-être dans la région de Haffé où elle formerait les premières pentes du massif.

2. *Surface d'érosion post-nummulitique et anté-vindobonienne* (S 2).

L'émersion accrue qui s'est produite après la transgression lutétienne durant l'Eocène supérieur, ou au moins durant l'Oligocène et le Burdigalien, a amené également une phase de pénéplanation dans le Djebel

[1] **14**, p. 33.
[2] **14**, p. 27.
[3] **9**, p. 77. Voir aussi : **17**, p. 54-55.
[4] **9**, p. 76.

Ansarieh septentrional. Au Miocène moyen en effet, la mer s'est infiltrée entre le massif du Djebel Akra et celui du Djebel Ansarieh par un couloir qui rejoignait l'Oronte dans la région de Djisr ech Chogour et qui se prolongeait jusqu'à l'Amouk. Elle y a déposé des calcaires et surtout des marnes qui, le long du Djebel Ansarieh, fossilisent tour à tour, de l'Eocène supérieur, de l'Eocène moyen, du Sénonien et du Cénomanien. Malgré la diversité de dureté de ces couches, leur ligne de contact avec le Miocène est régulière. En aucun point, ne sont visibles des reliefs nummulitiques ou cénomaniens fossilisés par les marnes néogènes, ce qui n'a pu se produire que si la surface pré-vindobonienne était déjà bien aplanie.

Pas plus que pour la surface anté-nummulitique, il n'est possible de dire si une partie du relief actuel lui est directement attribuable. Elle aussi a été très déformée, moins que la précédente puisque par définition elle a subi une phase orogénique de moins. Surtout elle a été reprise par les surfaces d'érosion postérieures comme elle même avait repris la surface anté-nummulitique. Dans la région du Djebel Tella (523 m.) près de Kfarié cependant, des lambeaux de Miocène qui recouvrent du Sénonien et du Nummulitique permettent de lui attribuer les premières pentes de la montagne. Il n'est pas impossible que la découverte d'autres témoins de Miocène ne se fasse ailleurs dans des conditions semblables.

3. *Surface d'érosion post-vindobonienne et anté-plaisancienne* (S 3).

— Dans le Djebel Ansarieh septentrional, L. Dubertret a déjà souligné qu'« en bordure de la baie pliocène (celle du Nahr el Kebir du Nord), on voit les argiles et les grès (du Plaisancien) reposer en discordance sur les couches tortoniennes ou éocènes redressées» [1] et qu'« ils (les argiles et les grès) se sont déposés sur le soubassement en légère discordance angulaire» [2].

Effectivement, le Plaisancien marin repose aussi bien sur le Miocène que sur l'Eocène moyen et le Sénonien.

[1] **10**, p. 96. [2] **10**, p. 94.

— Dans le Djebel Ansarieh central et méridional, ce même Plaisancien marin recouvre du Sénonien et du Cénomanien. En outre, il y est relayé par la grande nappe basaltique qui s'indente dans ses argiles ou qui les recouvre [1]. Cette nappe, ou ses débris, fossilise toutes les couches depuis le Nummulitique jusqu'au Jurassique (Pl. 6, A).

La surface post-vindobonienne et anté-plaisancienne est donc particulièrement évidente tout le long du massif. A la différence des deux surfaces précédentes, il ne s'agit plus avec elle de traces de pénéplanation qui ne subsisteraient que sur le bord de la montagne mais d'une surface qui s'étend sur toute sa partie méridionale et sur un secteur important de sa partie centrale, et cela depuis la mer jusqu'au faîte.

4. *Surface post-plaisancienne* (S 4).

Très fortement plissée après sa formation, la surface pontienne ne marque pas cependant la fin du travail de l'érosion qui s'est produit au Djebel Ansarieh. Plusieurs faits montrent qu'une nouvelle phase d'aplanissement s'est déroulée après elle.

a. Une coupe située à l'extrémité Nord du Liban et à proximité immédiate du Djebel Ansarieh a déjà été décrite [2]. Elle montre qu'au pied du Djebel Akroum, le Cénomanien et les basaltes plaisanciens ont été nivelés après le dépôt de ceux-ci. Il existe donc une dernière surface (S 4) qui est post-plaisancienne et qui a encore eu le temps d'être déformée après son aplanissement.

Il est très possible que des coupes semblables se retrouvent au contact septentrional des plateaux volcaniques d'Akkar avec le Djebel Ansarieh, la précédente se situant au Sud de ces plateaux. Des phénomènes équivalents se voient en Syrie intérieure et seront décrits ultérieurement.

b. La présence d'argiles plaisanciennes sur le bord du Djebel Ansarieh septentrional apporte de multiples preuves de l'existence de cette surface dans le Nord du massif bien que l'érosion récente ait fortement disséqué les couches très tendres du Pliocène et se soit glissée à leur

[1] **12** et carte géologique au 1/50.000e de Tartous.
[2] **2**, p. 46-47 et fig. 6, III.

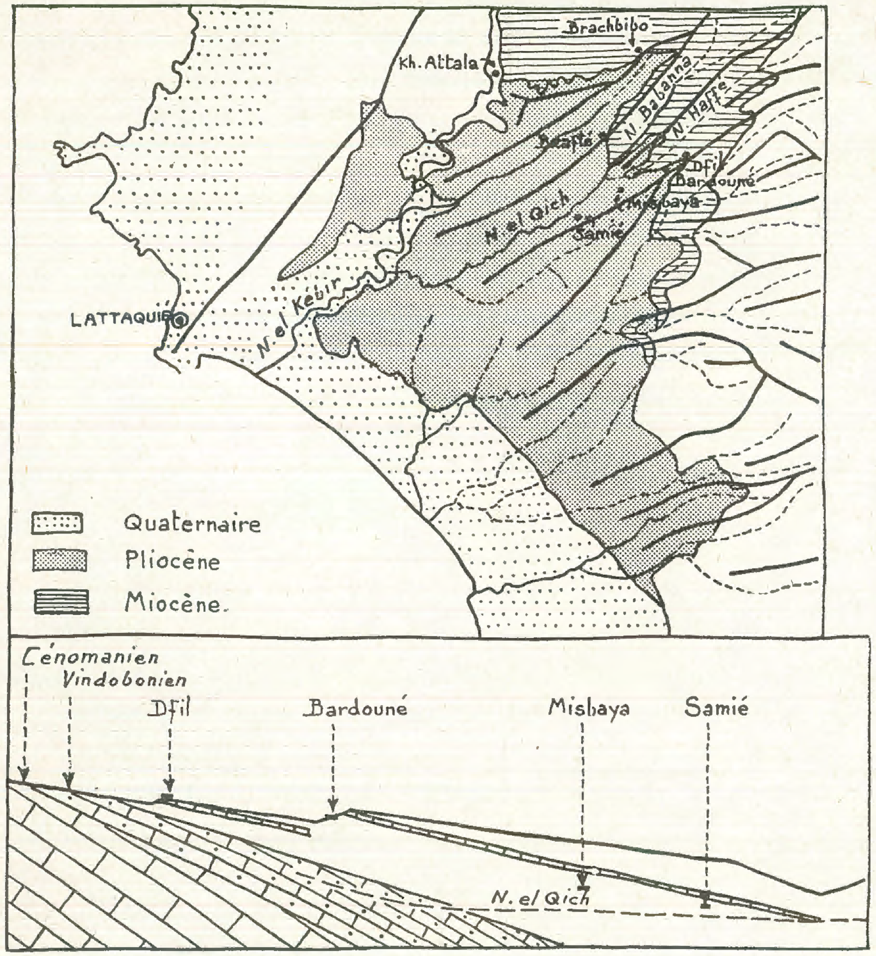

Fig. 2. LE GOLFE PLIOCÈNE DE LA RÉGION DE LATTAQUIÉ ET LA SURFACE D'ÉROSION POST-PLAISANCIENNE. Le tracé des affleurements stratigraphiques de la carte a été fait d'après L. Dubertret (10, page 95, fig. 39).

contact avec celles qui les supportent. Mais dans plusieurs cas, on peut constater que la surface qui s'étend sur le Plaisancien se poursuit sur le Sénonien (Coupe 7), ou sur le Nummulitique (Coupe 8), ou encore sur le Miocène et le Nummulitique (Coupes 5 et 6).

Au fond du golfe que le Plaisancien occupe à l'Est de Lattaquié, les dépôts argileux de celui-ci ont été découpés en lanières étroites.

L. Dubertret a fait déjà remarquer que le sommet de ces lanières correspond à « une surface régulière, s'abaissant légèrement vers le littoral actuel», ajoutant que « leurs sommets plats.... ne sont autre chose que les vestiges du fond de la mer au moment de l'exhaussement et l'exondation de la région»[1].

L'existence d'une surface tangente aux crêtes ne paraît pas pouvoir être niée en effet, quoiqu'elle ne soit pas en réalité parfaitement « régulière»[2]. Par contre, nous ne pensons pas que cette surface soit structurale et corresponde à l'ancien fond de mer plaisancien.

De nombreuses observations montrent en effet que cette surface doit être interprétée comme un aplanissement dû à l'érosion. Cette conclusion ressort bien de l'analyse du contact Miocène-Pliocène le long des crêtes où il est visible (figure 2, carte I).

— Ce contact affleure à 30 m. d'altitude à Khan Attala (point où la route Lattaquié-Alep traverse le Nahr el Kebir) sous une crête plaisancienne dont le sommet est à 164 m.; il monte régulièrement sur le versant septentrional de celle-ci et la rejoint au village de Brabichbo (300 m.). Le pendage du contact Miocène-Pliocène est donc beaucoup plus fort que celui de la crête qui monte seulement de 164 m. à 300 m. et qui révèle du Plaisancien avant Brabichbo et du Miocène après.

— Entre le Nahr el Kich et Brabichbo, le contact Miocène-Pliocène se fait de même au fond de la vallée à 80 m. sous une crête qui cote 198 m. Il rattrape celle-ci 3 km. plus loin près du hameau de Bzafté situé à 230 m. Ici également la crête s'étend d'abord sur le Plaisancien et ensuite sur le Miocène (Pl. 5, A).

— Entre le Nahr Babanna et le Nahr Haffé, la crête intermédiaire fournit des observations semblables. D'abord Pliocène, elle devient ensuite Miocène, elle est rejointe à 200 m. par le contact Miocène-Pliocène parti du fond de la vallée (80 et 100 m. selon les versants) alors qu'elle ne monte elle-même que de 168 à 200 m.

— Un phénomène concrétise admirablement le recoupement des strates par la surface topographique, c'est celui du banc gréseux qui est

[1] 10, p. 96. [2] Voir *infra*, p. 232, 242.

visible dans la vallée du Nahr el Kich (figure 2, carte et coupe). D'ordinaire, le matériel pliocène très uniforme ne laisse voir aucun plan de stratification, il existe toutefois une exception le long de la route de Lattaquié à Slenfé où un gros banc de grès formant corniche se suit aisément dans la masse des argiles plaisanciennes.

Il fait son apparition à 500 m. environ au S.-O. de Samié, tout au fond de la vallée, c'est-à-dire à 60-70 m. d'altitude alors que la crête qui le domine est à 110 m. (en fait à une altitude primitive plus forte car la cote 110 correspond à un col). Au hameau de Samié, le banc est à 100 m. et a déjà quitté nettement le fond de la vallée. Au-dessus du hameau de Misbaya, il cote 150 m. alors que le talweg est à 75-85 m. et la crête à 210 m. Il rejoint celle-ci à quelques centaines de mètres au S.-O. du hameau de Bardouné et y atteint l'altitude de 300 m. Au col situé à 200 m. au N.-O. de Bardouné un banc gréseux réapparaît un peu au-dessous de la crête et rejoint à son tour la crête où il forme un entablement qui porte le village de Dfil (320 m.).

Ainsi la crête recoupe successivement deux niveaux gréseux qui n'en sont peut-être qu'un car leurs rapports ne sont pas parfaitement clairs. Quoi qu'il en soit de leur relation, les conséquences qu'on peut tirer de l'observation de ce banc (ou de ces bancs) gréseux sont, elles parfaitement évidentes. Entre Samié et Bardouné, le premier niveau monte de 60 à 300 m. en l'espace de 4,5 km. tandis que la crête ne s'élève sur la même distance que de 193 à 300 m. Le second niveau lui aussi débute plus bas que la crête et se termine sur celle-ci. A supposer que les deux niveaux n'en soient qu'un, celui-ci monte de 60 à 320 m. en 6 km. 5 tandis que la crête ne s'élève que de 193 à 320 m. Dans tous les cas, le recoupement des strates par la surface des crêtes est certaine. Plus au N.-E., la surface définie par la crête se poursuit sur le Vindobonien et le Cénomanien arasés.

III. La surface polycyclique du Djebel Ansarieh

Avant de décrire l'extension des surfaces d'érosion dans le Djebel Ansarieh et de préciser le rôle qu'elles ont joué dans le façonnement

général du massif, il est nécessaire de regrouper les résultats obtenus par l'enquête précédente.

De toutes les coupes qui viennent d'être décrites, il résulte que le Djebel Ansarieh porte les traces de quatre pénéplanations.

Ce sont :

— S_1 qui est de l'Eocène inférieur,
— S_2 qui est de l'Oligo-burdigalien,
— S_3 qui est du Pontien,
— S_4 qui est de la fin du Pliocène-début du Quaternaire.

Chacune de ses surfaces a été aplanie durant la période d'exondation correspondante à son âge et a été plissée par les mouvements orogéniques qui se déroulaient en même temps. Elles sont d'autant plus déformées qu'elles sont plus anciennes et aussi d'autant plus reportées sur la bordure qu'elles remontent à une époque plus lointaine. Les surfaces les plus vieilles en effet ont été recoupées par les aplanissements plus récents de telle sorte qu'elles ne sont plus discernables les unes des autres. Comme au Liban, la violence des déformations subies par les surfaces successives, leur faible angle de recoupement mutuel, l'absence de dépôts à l'intérieur de la montagne (ceux des basaltes exceptés) rendent complètement impossible la reconstitution de la part qui est attribuable aux unes ou aux autres. La réalité observable est concrètement non pas une surface dont on peut reconstituer chaque facette mais une surface unique quoique polycyclique [1].

Tout au plus peut-on se poser le problème de savoir quelle a été la phase d'aplanissement la plus poussée. Là aussi la question est singulièrement difficile à résoudre en l'absence de tout dépôt corrélatif [2]. Les remarques suivantes sont donc à prendre comme des approximations qui pour être valables n'en sont pas pour autant des certitudes.

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[1] **2**, p. 40-44.

[2] Il existe bien des poudingues néogènes du côté oriental mais ils ont été jusqu'ici insuffisamment étudiés pour qu'on puisse tirer parti des enseignements qu'ils sont capables de fournir.

La surface de l'Eocène inférieur n'a été sans doute qu'une ébauche, un ravinement des reliefs antérieurs. Elle a abouti fréquemment à amincir la craie sénonienne mais ce n'est que rarement qu'elle l'a supprimée et qu'elle a amené les calcaires lutétiens déposés après son façonnement à reposer directement sur le Cénomanien.

La surface de l'Oligo-burdigalien paraît avoir abouti à un aplanissement plus poussé. Ainsi qu'on l'a déjà fait remarquer le Vindobonien qui l'a fossilisée ne recouvre pas de reliefs différenciés sur toute la longueur du couloir du Nahr el Kebir.

Aucune hésitation n'est plus permise en ce qui concerne la surface pontienne. Sans aucun doute possible, elle a atteint un degré très grand d'aplanissement dont le relief du Djebel Ansarieh méridional tout entier est un témoin certain. Partout dans ce secteur, la surface de base des basaltes plaisanciens, quelles que soient les couches tronquées sur lesquelles les laves reposent, ne montre la moindre irrégularité. Le Pontien a vu se parachever l'œuvre commencée au début et au milieu du Tertiaire et c'est à cette époque que le nivellement du Djebel Ansarieh a dû atteindre le maximum de perfection.

Quant à la dernière surface, celle de la fin du Pliocène-début du Quaternaire, il est difficile de s'en faire une idée précise. Si son existence est certaine, si en plus d'un point, elle a tronqué les dépôts marins ou les coulées basaltiques du Plaisancien, il n'existe aucun endroit où l'on puisse juger à coup sûr de son degré d'avancement. Celui-ci semble avoir été assez grand à en juger par le nivellement des basaltes, moindre si l'on considère la surface délimitée par les crêtes de l'ancien golfe de Lattaquié. En certains points de celui-ci en effet, les crêtes ne sont pas d'une régularité parfaite et montrent des buttes qui semblent être des reliefs résiduels [1].

Ces problèmes présentent toutefois moins d'importance pour l'explication proprement géographique du massif que la question de savoir le rôle que la surface polycyclique a joué dans le façonnement général du massif et par conséquent quels sont les restes qui subsistent dans celui-ci.

[1] Voir, *infra,* p. 242.

IV. Les restes de la surface polycyclique dans le relief actuel.

L'influence de la surface polycyclique dans le relief actuel est à la fois très grande et pratiquement nulle. Ses restes sont en effet partout et nulle part.

Cette constatation, paradoxale au premier abord, mérite d'être explicitée.

Sur les lisières du massif, la surface existe bien ici et là mais n'y occupe qu'une marge assez étroite. Son analyse se révèlerait par conséquent décevante si elle n'aboutissait qu'à cette conclusion.

L'exemple du Djebel Ansarieh méridional a l'avantage de souligner qu'elle exerce en fait une influence beaucoup plus grande. Dans ce secteur, le pays a beau être découpé par d'innombrables vallées, les crêtes qui séparent celles-ci ont beau être souvent très étroites, tous les points hauts du relief, sans en excepter l'anticlinal jurassique, lui sont tangents.

Il en est de même dans le Djebel Ansarieh central. Pour le Sud de cette région, le phénomène est aussi évident que pour le Djebel Ansarieh méridional car il s'y trouve de nombreux témoins de la nappe basaltique qui atteignent presque le parallèle de Qadmous. Ceux-ci mettent en évidence que la surface polycyclique demeure ici aussi tangente au relief jusqu'à la crête de la montagne. Là où il n'y a pas de reste de la nappe basaltique, on observe très fréquemment que les crêtes transversales de la montagne arasent les couches dont le pendage est plus fort que leur propre inclinaison. Le fait est frappant par exemple pour la crête de Mohammed Joufine au Nord de l'Ouadi Sramta. Le relief du Djebel Ansarieh central dérive donc immédiatement comme celui du Djebel Ansarieh méridional de la surface polycyclique qui subsiste sur tous les interfluves et plus largement sur les sommets.

Le problème du Djebel Ansarieh septentrional est plus délicat car, de toute évidence, il y existe des reliefs structuraux, en l'espèce l'escarpement des calcaires lutétiens qui donnent un crêt au-dessus des marnes sénoniennes. L'observation attentive du terrain permet cependant d'arriver aux mêmes conclusions que celles qui valaient déjà pour le reste du massif (Pl. 4, A).

S'il arrive que sur le revers du crêt nummulitique, les rapports de la surface topographique et du pendage des couches soient difficiles à déceler, il est des cas où ce revers recoupe obliquement les strates lutétiennes (Coupe 8), d'autres encore plus fréquents (Coupes 3, 4, 5, 6) où le Nummulitique diminue d'épaisseur depuis l'extérieur du massif jusqu'à la corniche formée par le crêt où il finit en biseau, d'autres enfin, plus rares mais particulièrement démonstratifs, où le crêt est dû au Sénonien, l'affleurement du Lutétien étant reporté sur le revers même du crêt et ne se traduisant pas dans la morphologie (Coupe 3) [1].

Le revers du crêt nummulitique représente donc bien d'une manière générale l'ancienne surface polycyclique. Celle-ci s'étend donc sur les points hauts jusqu'à 800-1000 m. d'altitude.

Peut-on considérer qu'à l'exemple des autres secteurs de la montagne, elle subsiste encore sur le faîte de celle-ci? Ici encore il faut répondre par l'affirmative.

Au delà de l'esquisse de dépression creusée dans la craie sénonienne, les assises du Cénomanien se redressent plus ou moins vite au contact de l'anticlinal jurassique. Transversalement elles sont découpées par des ravins dont les versants vont souvent jusqu'à se recouper les uns les autres. Les crêtes qu'ils délimitent cependant, si étroites qu'elles soient, permettent d'observer très souvent que leur sommet recoupe les couches (Coupes 4, 6, 7, 8), au contact du Jurassique, les terrains tendres de l'Aptien et de l'Albien pourtant favorables à l'érosion différentielle ont été à peine déblayés et ce n'est que par une minuscule ébauche de crêt (quand celui-ci existe) que le Cénomanien les domine (Coupes 6, 8, 9). Quant à l'ancienne surface que délimitent ces crêtes découpées dans le Cénomanien, elle se prolonge naturellement par les sommets de l'anticlinal jurassique (Pl. 3, A, B; 4, B; 6, B).

Le Djebel Ansarieh septentrional ne représente donc qu'une variante des observations qu'on pouvait faire déjà dans les deux secteurs voisins.

[1] Il existe des faits exactement semblables dans le crêt nummulitique de la Bekaa où la couche calcaire la plus dure ne forme pas toujours la corniche même du crêt.

§ IV. LE DÉGAGEMENT DU RELIEF ACTUEL

(Planche IV)

L'analyse de la structure et du façonnement général du massif par les périodes d'érosion passées permet de se faire une idée du volume montagneux avec lequel le cycle actuel s'est trouvé aux prises lorsque le Djebel Ansarieh eut récupéré son altitude à la suite de la dernière phase orogénique de la fin du Pliocène-début du Quaternaire.

Le relief primitif était défini par la surface polycyclique dont on a déjà fait remarquer à plusieurs reprises que toutes ses déformations épousaient exactement celles des couches qu'elle nivelait. Les grands accidents morphologiques sont donc ceux de la structure [1]. L'influence de la surface polycyclique est cependant très importante. D'abord parce qu'elle élimine dans le relief toute surface structurale, ce qui donne à celui-ci un aspect particulier. Egalement du fait qu'elle livrait à l'érosion au début du cycle actuel un volume montagneux dont la surface primitive recoupait successivement toutes les couches depuis celles du Nummulitique jusqu'à celles du Jurassique, assises parmi lesquelles se trouvaient des lignes de faiblesse, notamment celles que constituaient les affleurements de l'Aptien-Albien et du Sénonien. Même si ces lignes de faiblesse n'ont été encore que peu exploitées par l'érosion différentielle par suite de leur peu d'importance, par suite aussi de la jeunesse du cycle actuel, elles n'ont pas moins commandé une évolution morphologique sensiblement différente de celle qui se serait déroulée si le massif avait été constitué par une carapace uniforme due à une même couche comme c'est le cas dans l'Anti-Liban par exemple.

Il reste donc à voir comment a travaillé l'érosion depuis le début du cycle et quelles sont les principales formes qu'elle a dégagées.

[1] Voir l'introduction du § III, p. 221.

I. Le tracé du réseau hydrographique.

Après la structure d'ensemble et la surface polycyclique, c'est le réseau hydrographique qui commande au Djebel Ansarieh les dispositions morphologiques les plus importantes.

Sur la bordure N.-W. de la montagne, le Nahr el Kebir septentrional utilise le couloir déprimé qui sépare celle-ci du massif du Djebel Akra. Son tracé est donc adapté à la structure dans ses très grandes lignes mais dans ses très grandes lignes seulement car il n'occupe certainement pas l'axe même du synclinal qui a fixé son cours pour la première fois et il révèle de nombreuses et importantes épigénies. Il est vraisemblable aussi qu'il a perdu une partie de son bassin au profit de celui du Nahr el Abiad (affluent de l'Oronte) dont l'érosion régressive se montre plus active que la sienne [1].

Au Djebel Ansarieh proprement dit, le réseau hydrographique est bien adapté dans son ensemble à la structure. La crête de la montagne correspondant à l'anticlinal jurassique et à l'axe de déformation majeure de la surface polycyclique sert partout de ligne de partage des eaux. En aucun point, les torrents du versant oriental n'ont pu la forcer encore malgré la très grande étroitesse de ce versant et l'altitude très déprimée du niveau de base. Tout le réseau hydrographique est donc conséquent par rapport à la surface polycyclique et à la structure et fait montre d'une grande jeunesse.

Quelques adaptations à la structure locale sont cependant discernables çà et là. Il y a des débuts de tracés subséquents ; ainsi au Sud de Slenfé sur la bordure du bombement que forme en cet endroit l'anticlinal jurassique (Coupe 5) ; de même au S.-E. de Qerdaha (Coupe 8).

Quant à la zone de l'Aptien et de l'Albien, elle n'a pas encore été dégagée dans le Djebel Ansarieh septentrional et n'y a pas donné naissance à des talwegs longitudinaux (Coupes 4, 5, 7, 8). C'est à peine si dans certains cas, une esquisse de crêt cénomanien y a été ébauchée (Coupes 6, 9). La structure plus calme du Djebel Ansarieh central a permis au contraire ce début d'évolution. L'ouadi Ismaïl a un tracé

[1] La question du Nahr el Kebir sera reprise ultérieurement.

N.-S. sur 8 km. de longueur et le doit probablement au fait d'avoir été fixé dans cette orientation par l'affleurement du Crétacé inférieur (Coupe 11). Dans le cas de l'Ouadi Mhesroun, la fixation du tracé longitudinal par les couches de l'Aptien et de l'Albien est certaine mais le talweg a déjà dépassé ce stade d'évolution et se trouve enfoncé épigénétiquement dans le Jurassique dont le pendage est très faible (Coupe 13). Le même processus évolutif existe dans le Djebel Ansarieh méridional où un talweg d'orientation longitudinale fixé primitivement par l'affleurement de l'Aptien et de l'Albien est incrusté maintenant dans le Jurassique (Coupe 16).

Malgré les quelques cas qui viennent d'être cités, il faut bien reconnaître que d'une manière générale la zone tendre du Crétacé inférieur n'a encore été que très peu exploitée par l'érosion. Le Djebel Ansarieh à ce point de vue ne connaît rien de comparable à ce qui se passe au Liban où les bordures du Djebel Jaje et du Djebel Barouk-Djebel Niha sont soulignées par des alignements de talwegs longitudinaux à peu près continus. Ce phénomène s'explique par la vigueur moindre de l'érosion dans une montagne beaucoup moins soulevée et surtout par le fait qu'au Djebel Ansarieh, le Crétacé inférieur est bien moins développé et beaucoup moins meuble qu'il ne l'est au Liban.

L'autre zone de faiblesse que représentait sur le relief primitif, l'affleurement de la craie sénonienne, a été elle aussi exploitée par l'érosion. Pas plus cependant que dans le cas précédent, elle n'a pu donner naissance à des talwegs longitudinaux. Très peu épaisse, elle n'a pas été pour l'érosion une occasion de s'enfoncer profondément dans la structure et n'a pu faire prévaloir même localement les tracés longitudinaux sur les tracés transversaux.

Les seules orientations des talwegs qui échappent à celles précédemment décrites sont celles, très rares, qui sont dues à des failles. Dans le Djebel Ansarieh septentrional, la faille qui se trouve sous le Signal de Barza est suivie par un talweg de 6 à 7 km. de longueur (Coupes 2, 3). Dans le Djebel Ansarieh méridional surtout, la fracture libano-syrienne a donné naissance à deux gorges très profondes qui au contact du Djebel Ansarieh et du Djebel Helou sont disposées sur le même alignement N.-S.

Le tracé du réseau hydrographique est donc en général très simple. Les quelques adaptations locales à la structure actuelle et les quelques épigénies qui existent au Djebel Ansarieh ne peuvent voiler le fait primordial qui est son allure presque toujours conséquente par rapport à la surface polycyclique. Cette constatation comme l'uniformité du matériel rocheux mis en œuvre laisse prévoir que les formes dégagées par l'érosion ne sont pas d'une grande variété.

II. Les formes de relief du Djebel Ansarieh.

Comparé au Liban où existe une grande richesse de forme de reliefs le Djebel Ansarieh fait pauvre figure.

1. *Les gorges.*

Ce sont elles qui donnent sa physionomie au paysage. Partout du Nord au Sud de la montagne, elles sabrent celle-ci et y rendent les communications pratiquement impossibles dans le sens longitudinal. Le massif ayant un profil en long très tranquille et dépourvu d'ensellements locaux, le drainage ne s'est concentré nulle part sur le flanc occidental du Djebel Ansarieh; les artères de drainage sont donc multiples, juxtaposées les unes aux autres sans qu'aucun intervalle important ne les sépare. De là, l'impression de fouillis que donne le relief. Dans leur section transversale, les gorges ont des parois abruptes dues à la dureté des calcaires cénomaniens dans lesquels elles se sont encaissées; dans certains secteurs où le Crétacé moyen est fait d'une alternance de couches dures et d'autres plus tendres, les flancs des canons montrent une succession de corniches et de pentes obliques; rien cependant d'assez marqué pour rompre la monotonie générale. Lorsque les gorges ne sont pas nettement conformes à l'inclinaison générale des couches et qu'elles lui sont plus ou moins obliques, a fortiori lorsqu'il s'agit d'un tracé nettement subséquent, ces gorges affectent une allure dyssymétrique : leur versant occidental prend des allures de crêt tandis que leur versant oriental tend à l'allonger et à devenir plus ou moins conforme au pendage des couches. Ici encore, rien qui introduise une originalité vraiment nette dans le paysage.

2. *Le crêt lutétien.*

La seule vraie originalité du Djebel Ansarieh au point de vue de la morphologie structurale est l'enceinte que forme autour de la partie septentrionale de l'anticlinal jurassique le crêt nummulitique.

Depuis le Nord du massif jusqu'au moment où les affleurements lutétiens disparaissent, il est presque partout présent. Sur son bord interne, les marnes sénoniennes ont été si bien raclées que le Cénomanien montre sa surface structurale; ainsi à el Ouata — coupe 4 — et à el Baqa — Coupe 6 — seuls cas où dans toute la montagne des reliefs soient formés par le plan même des couches.

Le dégagement du crêt s'est en général bien opéré mais sans que celui-ci atteigne cependant toute la vigueur que l'on en attendrait. Sur leur limite intérieure en effet, les calcaires lutétiens par suite de l'amenuisement que leur ont fait subir les cycles d'érosion antérieurs sont très peu épais et ne peuvent donc pas donner une corniche très vigoureuse au-dessus des marnes sénoniennes (Coupes 5, 6 par exemple). La jeunesse du cycle actuel n'a pas même permis par ailleurs à l'érosion en certains cas de faire reculer les marnes sénoniennes jusqu'à l'affleurement du Lutétien de telle sorte que ce sont celles-ci qui donnent le crêt et non pas les calcaires qui les surmontent (Coupe 3).

Sur tout le plateau intérieur, le crêt nummulitique est d'ailleurs très morcelé et se résoud bien souvent en une suite de buttes-témoins plus ou moins importantes. Le morcellement de la couverture nummulitique par les ravins transversaux, rendu d'autant plus facile que celle-ci est relativement peu épaisse, en est responsable. Les conditions dans lesquelles travaillent ici l'érosion et qui la rendent particulièrement active méritent aussi d'être signalées. Les entablements lutétiens sont presque horizontaux; très perméables, ils absorbent facilement toutes les eaux qui sont précipitées sur eux et qui percolent aisément jusqu'à la surface de contact des marnes sénoniennes. Celles-ci infiniment moins perméables que les couches qu'elles supportent, donnent par suite une surface de discontinuité au point de vue hydrologique. Partout où cette surface affleure, elle est marquée par des petites sources qui permettent aux hommes de s'établir sur la vire séno-

nienne située entre la corniche nummulitique et les gorges cénomaniennes. Au point de vue morphologique, cette surface se comporte comme un plan lubréfié qui provoque dans les calcaires, partout où la pente est favorable, des cassures qui peuvent atteindre plusieurs centaines de mètres. Dès que l'affouillement des marnes qui supportent les blocs ainsi préparés est assez avancé, des glissements ou des effondrements se produisent de telle sorte que la vire sénonienne est souvent encombrée de blocs qui réduisent d'autant un des seuls coins de la montagne où l'homme peut agripper quelque peu ses champs et ses maisons (Pl. 5, C).

L'existence de la pliure bordière de la montagne introduit un nouvel élément de diversification dans ce crêt nummulitique. Dans tous les endroits où elle est assez prononcée, elle a amené la formation d'un crêt que l'épaisseur des couches, ici beaucoup plus grande, et que le pendage accru de celui-ci rend bien plus vigoureux que les corniches dessinées plus à l'Est par les buttes témoins qui le précèdent. La séparation de ce crêt et des buttes témoins est fonction de la vigueur de la pliure bordière ; là où celle-ci est bien marquée, crêt et buttes sont séparés, c'est le cas sur la bordure Ouest de la montagne ; là au contraire où elle est très faible comme c'est le cas sur la lisière N.-W. du massif, le crêt du chevron de la bordure tend à se prolonger vers l'intérieur de celui-ci par d'étroites lanières qui occupent les interfluves des gorges.

3. *La façade orientale.*

Sa morphologie se caractérise par sa très grande jeunesse. Malgré le rapprochement très grand de la crête et du niveau de base, le versant oriental n'a guère eu le temps encore d'évoluer. Entre Djisr ech Chogour et en Naour, l'érosion n'a entaillé que quelques gorges, dégagé quelques corniches et fait sauter ici et là la charnière de la pliure en bas du versant. Le long de la partie méridionale du Rhâb, la façade montre un escarpement extrêmement abrupt qui est dû à la fraîcheur de la fracture qui l'a provoqué. En aucun point cependant n'existe encore de ravin qui ait créé des échancrures dans la crête qui ici comme partout ailleurs est rectiligne et continue.

La même jeunesse de formes se retrouve en bordure de la cuvette d'Acharné et du plateau de Massiaf où le versant oriental du Djebel Ansarieh, beaucoup plus développé qu'il ne l'est au Nord, ne voit sa dissection que commencer. Il n'y a guère qu'au-dessus d'Aïn Halaqim que l'existence d'un niveau plus marneux dans les assises jurassiques a permis la formation d'une grande demi-combe qui rappelle un peu celle du Djebel Barouk au-dessus de la Bekaa.

Nulle part le relief n'a eu encore le temps d'évoluer.

4. *Le Karst.*

Malgré la prépondérance presqu'exclusive du matériel calcaire, le Djebel Ansarieh est pauvre en formes karstiques.

Il n'y existe aucun poljé. Le massif est trop étroit, ses niveaux de base trop proches, ses pentes trop fortes pour que le ruissellement n'ait pas eu l'avantage sur l'infiltration. La structure du massif est également trop simple pour avoir favorisé la formation des poljés : la fracture libano-syrienne ne passe pas ici, comme dans le Liban septentrional en plein milieu d'un versant oriental très élargi, il n'y a pas non plus de grandes surfaces calcaires subhorizontales comme au Makmel, pas de synclinal périphérique comme à l'Hermon. L'infiltration n'était invitée par aucun accident à se concentrer en certains points et à y donner de grandes dépressions fermées.

Dans ces conditions, les formes karstiques se ramènent à des formes mineures. Les calcaires nummulitiques se distinguent par l'abondance de leurs lapiez très profonds et souvent finement ciselés, par l'abondance de la terra rossa qui provient de la décalcification de ses calcaires et qu'elle rend reconnaissables de loin par le ton rosé qu'elle leur donne. Par contre, les dolines y sont très rares. Elles sont complètement absentes dans le Cénomanien qui n'offre nulle part de grandes surfaces horizontales. Seul, le Jurassique montre sur les crêtes un modelé karstique vraiment caractéristique. Les roches souvent dolomitiques ont un aspect ruiniforme mais surtout elles sont criblées de dolines partout où les assises sont à peu près horizontales. Cinq d'entre elles méritent d'être signalées par leur proportion gigantesque. Elles se trouvent sur la crête de

la montagne au Sud du col de Jaoubet Bourghal et sont alignées dans le même sens qu'elle (Coupes 7, 8). Leur longueur varie de 700/800 m. à 1400/1500 m., leur largeur de 500 à 900 m. Quant à leur profondeur, elle ne mesure pas moins de 150/200 m., 342 m., 275 m., 273 m., 150 m. En aucun point des massifs levantins ne se rencontrent de phénomènes semblables.

5. *Les lanières pliocènes de Lattaquié.*

La région formée par l'ancien golfe pliocène de Lattaquié a une morphologie très spéciale. On a vu plus haut que son matériel argilo-sableux en pente vers l'Ouest, avait été recoupé par une surface d'érosion qui se tient au niveau des crêtes actuelles et qui a été elle-même déformée après son aplanissement. Cette surface des crêtes sur laquelle on n'a dit précédemment que l'essentiel touchant l'évolution générale du massif mériterait des recherches plus détaillées. Aux environs de Haffé en effet, les crêtes ne sont pas parfaitement nivelées mais montrent des reliefs résiduels qui tiendraient à prouver que la surface d'érosion post-plaisancienne n'a pas eu le temps d'être aplanie complètement avant que les talwegs ne la dissèquent (Pl. 5, A).

Actuellement le trait le plus caractéristique du paysage est cette dissection du pays pliocène de Lattaquié. Toute la région est découpée en lanières étroites qui descendent de l'amont à l'aval. Leurs versants sont concaves et très raides dans la partie supérieure. Ils se recoupent assez souvent et donnent naissance parfois à des pyramides aiguës. Un peu partout le ravinement actuel fait fureur et engendre des zones de bad lands infranchissables. Mais là aussi l'étude de la morphologie de ces vallées mériterait d'être plus poussée car les versants ne sont pas partout aussi simples qu'on l'a dit plus haut. En de nombreux points, ils laissent voir des replats qui donnent l'impression de vallées emboîtées les unes dans les autres et qui marqueraient les différents stades du creusement quaternaire. Les formes cependant semblent trop discontinues pour qu'on ait vraiment chance d'arriver à une reconstitution précise. Aucune observation par ailleurs ne laisse espérer non plus qu'on puisse raccorder ces replats avec les terrasses marines. Le matériel pliocène est trop fragile pour avoir gardé durablement des empreintes de cette sorte, au moins sur des longueurs assez grandes pour permettre des reconstitutions morphologiques.

§ V. CONCLUSIONS

Les principales conclusions touchant le Djebel Ansarieh ayant été dégagées au cours des paragraphes de cette étude, il n'est plus besoin que de les résumer brièvement pour montrer comment elles se coordonnent entre elles.

Les résultats acquis entraînant des conclusions plus générales sur les pays limitrophes, notamment sur la Bekaa, on disjoindra celle-ci sous forme d'une note complémentaire sur la grande dépression qui s'allonge entre le Liban et l'Anti-Liban.

En ce qui concerne le Djebel Ansarieh, les principaux points mis en relief sont les suivants :

1. *Le Djebel Ansarieh est un pli de fond à grand rayon de courbure.*

D'une de ses extrémités à l'autre, toute son architecture est commandée par le plissement des couches. Le rôle des failles à l'intérieur du massif est pratiquement nul et leur répercussion sur la structure et la morphologie est extrêmement minime. Le style a beau changé du Nord au Sud, le caractère plissé du Djebel Ansarieh ne fait pas de doute. Il doit être interprété comme un anticlinal à grand rayon de courbure qui se termine par deux plongées périclinales. Il est vraisemblable, vu sa largeur, que ce pli a intéressé le socle lui-même et qu'il est à ranger par conséquent dans la catégorie des plis de fond et non dans celle des plis de couverture.

2. *C'est un pli d'une très grande simplicité.*

A la différence de l'Anti-Liban et surtout du Liban dont les voûtes sont affectées de déformations secondaires et, dans le cas du second, de bourrelets marginaux et de plis bordiers (les plissements pré-libanais), le Djebel Ansarieh a une structure très simple, plus

simple même que celles du massif galiléen, du massif palestinien ou de la dorsale du Negeb [1].

Le style de ses secteurs septentrional et méridional rappelle celui de l'Anti-Liban et du Liban méridional tandis que le style de son secteur central s'apparente à celui du Liban septentrional ou de la Galilée libanaise. Dans tous les cas, son profil est beaucoup plus schématique que celui de ses voisins du Sud.

3. *C'est aussi un pli dont la courbure des couches ne se fait pas de manière régulière mais par pliure et par contre-pliure.*

Ici comme dans tous les massifs du Proche-Orient, les déformations ne montrent pas des couches régulièrement courbées mais des strates dont les pendages subissent de brusques accélérations ou des atténuations rapides. Le rôle des plis en genou que nous avons appelés pour la commodité pliures et contre-pliures est caractéristique du Djebel Ansarieh.

Le Djebel Ansarieh comme tous ses congénères orientaux relève du style des « plis coffrés» [2] mais de tous les massifs levantins, c'est certainement lui qui est le moins typique à cet égard. Aucune de ses pliures et contre-pliures ne parvient à la brusquerie de celles du Liban ou de l'Anti-Liban et n'a une influence aussi forte sur le relief. Ici encore le Djebel Ansarieh est plus simple que ses voisins.

Il est à noter qu'à l'exemple de ce qui existe dans les autres massifs, ces pliures et contre-pliures ne sont pas des flexures si l'on entend par là qu'un étirement des couches s'y produit. Dans deux cas, sur la bordure N.-O. du massif, elles sont relayées par des failles de quelques kilomètres de longueur. D'une manière générale, les grandes fractures sont indépendantes d'elles et ne suivent pas les mêmes tracés quoique ceux-ci leur soient quelquefois parallèles. Il ne semble donc pas légitime d'y voir l'amorce des grandes cassures qui existent dans l'architecture du Proche-Orient occidental.

[1] Sur la Galilée et la Palestine, voir : **2** et L. Picard, *Structure and evolution of Palestine.* Jerusalem, 1943. Sur le Negeb, voir : **20** et les ouvrages qui y sont cités.

[2] Appelés « plis à section carrée» dans : **19**.

4. *C'est encore un pli dyssymétrique.*

A l'image du Liban, de l'Anti-Liban et de la Galilée libanaise, le versant Ouest est beaucoup plus développé que le versant Est qui retombe avec beaucoup de rapidité sur le Rhâb, la cuvette d'Acharné et le plateau de Massiaf.

Quoique certaine, cette dyssymétrie est cependant accentuée par les grandes fractures qui longent son bord oriental et qui masquent une partie du flanc Est, soit qu'il se trouve déprimé sous les alluvions, soit qu'il soit nivelé comme dans le plateau de Massiaf.

5. *C'est enfin un pli dysharmonique.*

Pas plus encore qu'au Liban, les couches n'ont conservé leur parallélisme en se plissant, de telle sorte qu'on est en présence, comme dans ce dernier massif, de deux structures superposées : celle du Jurassique plissée très violemment et celle du Cénomanien plus tranquille et plus calme. Le fait est particulièrement apparent au Nord du Djebel Ansarieh où l'anticlinal jurassique plonge sous une voûte cénomanienne à grand rayon de courbure. Le Crétacé inférieur a joué ici aussi le rôle d'un « matelas amortisseur» [1] qui a atténué une partie des déformations grâce à sa plasticité. Une nouvelle fois encore il faut reconnaître cependant que la structure est aussi plus simple dans ce domaine qu'elle ne l'est ailleurs. L'amenuisement de l'Aptien et de l'Albien au Djebel Ansarieh, la disparition de ses horizons les plus plastiques comme de ceux du Néocomien, font que la dysharmonie des structures du Jurassique et du Cénomanien y est beaucoup moins poussée qu'au Liban.

6. *Quant aux fractures, leur origine semble bien relevée de phénomènes structuraux différents.*

Elles sont surimposées à la structure du Djebel Ansarieh, elles n'en dérivent pas.

[1] Voir : **2**, p. 30-34 et fig. 3. Au Djebel Ansarieh on est dans la situation du schéma II de cette figure.

La fracture occidentale du Rhâb recoupe, quoique sous un angle très faible, l'anticlinal septentrional. Au pied de celui-ci dans le Nord, elle passe à l'Ouest de sa charnière dans le Sud. Elle ne se comprend bien que dans le cadre de la structure du Rhâb.

La fracture libano-syrienne, elle, est au contraire parallèle au pli mais pas plus qu'au Liban, elle n'en suit un accident majeur. Elle se localise en plein milieu de la retombée orientale de l'anticlinal sans qu'il soit possible de dire le motif qui l'a fixée sur cet emplacement.

7. *Place du Djebel Ansarieh dans la structure du Proche-Orient.*

Les conclusions qu'on peut tirer de l'étude du Djebel Ansarieh confirment bien ce que nous avions dit sur la place qu'il tient parmi les autres massifs levantins [1].

Elles se ramènent aux constatations suivantes.

— *Le Djebel Ansarieh ne forme avec le Liban qu'un seul et même anticlinal qui se prolonge à son autre extrémité par le massif galiléen.*

Orienté d'abord N.S. (Djebel Ansarieh), puis N.N.E.S.S.O. (Liban), cet anticlinal devient par la suite franchement N.E.S.O. (Galilée). *Il est donc d'orientation taurique* et représente un des plis de fond qui s'est propagé dans le socle syrien en avant des chaînes géosynclinales d'Anatolie. Sa dyssymétrie s'explique bien dans l'hypothèse d'une poussée orogénique venue du N.O. Quant à la dysharmonie du plissement qui montre un Jurassique beaucoup plus déformé que le Cénomanien, elle donne à penser que cette poussée orogénique a agi principalement en profondeur, au niveau de la tranche du Jurassique.

— *La fracture libano-syrienne et la fracture transjordanienne qui la relaye en Palestine, si on les considère sur toute leur longueur, recoupent les plis* bien qu'elles puissent leur être parallèles par endroits. *Il n'est donc pas possible de les interpréter comme une simple résultante des plissements.* Leur explication réside essentiellement dans l'effondrement de la marge maritime du socle qui, trop soulevé, a tendance à retrouver son équilibre isostasique

[1] **19**.

par une fragmentation marginale qui pousse le bloc côtier à s'affaisser. Ce qu'on sait des anomalies gravimétriques confirme cette manière de voir. Cette théorie rend bien compte de l'abaissement en masse de la Palestine au-dessous de la Transjordanie et du début d'enfoncement qui s'est réalisé au Liban, au moins dans certains endroits. Au Djebel Ansarieh, l'exhaussement du massif au-dessus du socle syrien est encore général. La différence de comportement des trois ensembles montagneux montre que l'effondrement marginal du socle se réalise mieux au Sud qu'au Nord où le relâchement des forces orogéniques qui soutenaient le bloc côtier a tendance à être plus tardive.

8. *Au point de vue morphogénétique et morphologique,* les principales acquisitions qu'apporte le Djebel Ansarieh se ramènent aux mêmes résultats que ceux qui découlaient de l'étude du Liban. Aussi n'est-il pas nécessaire de faire plus que de les rappeler rapidement. Ce sont :

— *L'existence d'une surface polycyclique dont les phases de formation sont exactement concomitantes de celles qui ont assuré la surface du Liban et de l'Anti-Liban.* L'évolution morphologique est donc la même dans les deux cas et a été, semble-t-il, similaire en Palestine, dans le Negeb et en Syrie intérieure.

— *L'aplanissement particulièrement poussé au Pontien.* Cette conclusion découlait au Liban de l'observation des poudingues de cette époque. Au Djebel Ansarieh elle est directement observable par suite de la fossilisation de la surface de cette époque par les basaltes plaisanciens. La surface polycyclique, ébauchée à l'Eocène inférieur et à l'Oligo-burdigalien, y apparaît surtout comme une surface pontienne, reprise après le Plaisancien.

— *La très grande jeunesse du cycle actuel* qui n'a pas eu le temps de faire plus que d'entailler des gorges et de dégager quelques petits reliefs structuraux.

LA STRUCTURE DE LA BEKAA
NOTE COMPLÉMENTAIRE

SOMMAIRE

La Bekaa a été interprétée très longtemps comme un élément du « fossé syrien » qui du golfe d'Akaba jusqu'à Marach au pied du Taurus, était sensé continuer, en plein Proche-Orient et jusqu'aux abords immédiats des chaînes tauriques les grands effondrements de l'Afrique orientale et de la Mer Rouge.

Selon cette théorie, l'essentiel des accidents structuraux et morphologiques était imputé à des failles. Les plissements, pourtant manifestes dans les massifs levantins, étaient à peine évoqués, souvent passés sous silence.

Le premier problème à élucider en ce qui concernait la Bekaa était donc celui de sa structure transversale.

I. La structure transversale de la Bekaa

A la suite de nos recherches sur cette dépression et sur les massifs qui l'encadrent, nous pensons avoir démontré que la Bekaa est essentiellement un synclinal à grand rayon de courbure qui commande non seulement la structure mais encore toute la morphologie [1].

Du côté de l'Anti-Liban, ce n'est que sur un très petit parcours qu'une faille — celle de Serrhaya — a contribué à approfondir un peu par son rejet l'enfoncement de la dépression. Plus au Sud en effet, les failles

[1] 2.

de Chebaa et de l'Hermon, outre qu'elles ne bordent pas la Bekaa et qu'elles recoupent obliquement l'Anti-Liban méridional, ont des regards qui lui tournent le dos.

Du côté du Liban, la fracture libano-syrienne est certes un accident majeur. L'analyse de ses rejets prouve cependant que ceux-ci sont incapables de rendre compte du dénivelé topographique de la dépression. Bien plus, dans deux cas (celui du Sannin et celui de l'Akroum), ils ont joué en faveur d'un abaissement structural du bloc libanais.

Le caractère synclinal de la Bekaa, l'inexistence de quoi que ce soit entre elle et le Rhâb qui puisse ressembler à un fossé, l'absence de faille importante et continue sur le bord occidental du Ghor, appelaient une nouvelle synthèse structurale du Proche-Orient que nous avons tenté de faire [1]. L'accent n'y est plus mis sur le « fossé syrien » mais sur les plissements et sur deux fractures — la fracture libano-syrienne et la fracture transjordanienne — qui délimitent un bloc côtier indépendant du socle syrien.

Le problème de la structure transversale ainsi résolu, il restait celui de la structure longitudinale dont la solution ne se laisse pas découvrir sur le territoire même de la Bekaa et qui demeurait en suspens.

II. La structure longitudinale de la Bekaa

1. *Position du problème.*

La vue d'une carte, même à petite échelle, laisse apparaître deux faits insolites.

Le premier est l'obturation de la partie méridionale du sillon de la Bekaa par le Djebel Rharbi, masse de calcaire nummulitique qui demeure pincé entre Liban et Hermon et qui culmine à 1508 m., c'est-à-dire à près de 500 m. au-dessus du col de Baalbeck. Il semblerait donc au premier abord que le Litani qui descend de celui-ci ait vu son passage interdit par ce massif en direction du Sud.

En réalité, ce cas ne fait pas de difficulté car le Litani a trouvé ici entre le Djebel Rharbi et le Liban, un synclinal des couches et de la surface

[1] 18, 19.

polycyclique dont le fond est nettement au-dessous de la ligne de partage des eaux de Baalbeck et descend du Nord au Sud.

Le second est le drainage de la Bekaa par le Litani et l'Oronte qui s'écoulent en sens opposé. Leur divergence s'opère à peu près au milieu du sillon et le fait d'une manière encore plus paradoxale entre les deux avancées des avant-monts libanais correspondant aux culminations du Makmel et du Sannin. Le drainage de la Bekaa paraît, au moins à première vue, complètement indépendant de la structure. Le problème consiste donc à savoir quels sont les rapports exacts qui existent entre eux, ce qui revient à construire le profil longitudinal de la structure de la Bekaa.

2. *Profil longitudinal de la Bekaa* (figure 3).

Nous avons pensé précédemment que l'entreprise était presque impossible, ce qui nous avait amené à écrire : « Le profil longitudinal de la dépression centrale est très difficile à restituer. On ne peut en effet ni fixer avec exactitude l'emplacement précis de son axe, ni observer le long de celui-ci des cotes qui soient au contact de deux étages stratigraphiques, ni observer directement le pendage des couches comme on pouvait le faire au Liban. Tout le fond de la dépression est remblayé en effet et les matériaux détritiques masquent complètement dans la Bekaa l'armature profonde du synclinal.

Un point se présente comme certain. Le Djebel Rharbi ne peut être interprété autrement que comme une culmination structurale du sillon » [1].

Ce texte et les interprétations qu'il contient sont en fait à nuancer et même à corriger fortement. Le Djebel Rharbi est bien une culmination de la surface polycyclique grâce à l'épaisseur accrue que le Nummulitique a dans ce secteur, du fait aussi qu'il a été beaucoup plus érodé dans le reste de la Bekaa qu'il ne l'a été dans cet endroit. Il n'a pas fait obstacle cependant au passage du Litani qui trouvait sur sa bordure un synclinal où s'engager. Surtout il ne correspond pas à une culmination de la structure comme on va le voir.

[1] 2, p. 98. Voir aussi p. 122-124.

La Bekaa en effet n'est pas remblayée partout comme nous le pensions par les poudingues néogènes. Des affleurements crétacés se montrent au milieu de ceux-ci sur l'axe même du synclinal ou à proximité immédiate de celui-ci [1]. Ils sont assez nombreux et surtout placés en des points suffisamment heureux pour que la restitution du profil longitudinal de la Bekaa soit rendue possible [2].

— A Joub Jennine, sur le bord du synclinal qui sépare le Djebel Rharbi du Liban, le contact Cénomanien-Sénonien est à 900 m. Il devait être plus bas encore sur l'axe même du synclinal avant que l'érosion n'y fasse disparaître le Nummulitique et le Sénonien.

— De là, il s'enfonce en direction du Sud. La gorge du Litani ne l'atteint nulle part et il ne se fait jour à nouveau qu'à l'extrémité du Merjayoun, c'est-à-dire à 500 m. d'altitude.

— Vers le Nord, il a toute chance de plonger à une assez grande profondeur car la Bekaa méridionale voit disparaître sous son remblaiement alluvial non seulement ce contact Cénomanien-Sénonien mais aussi tout le Nummulitique du Djebel Rharbi qui le recouvre.

— Près du village de Yaate (N.W. de Baalbeck), un affleurement

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[1] L'affleurement du Nummulitique, du Sénonien et même parfois du sommet du Cénomanien dans le centre de la Bekaa ne change rien à sa nature synclinale (Voir **2**, p. 93-95). Les chiffres donnés concernent d'abord en effet, *la flèche visible* de ce synclinal et il n'y a rien à y modifier. Quant à ceux concernant *la flèche réelle,* nous avions volontairement sous-estimé l'épaisseur du Néogène, du Nummulitique et du Sénonien en ne lui attribuant que 200 m. Même en défalquant ces 200 m. là où le Crétacé apparaît, on s'aperçoit que les raisonnements des pages 93-95 de notre thèse restent entièrement valables.

[2] Voir L. Dubertret, *Carte géologique du Liban au 1/200.000e* (1 carte et 1 notice de 74 pages, 30 figures, 8 planches photographiques). Beyrouth, 1955. L'auteur dit dans sa notice (p. 6) : « La bibliographie a été donnée aussi complète que possible». Il est étonnant dans ces conditions que soit cité à la page 70 l'article de L. Dubertret, *La structure du Proche-Orient d'après Etienne de Vaumas* (*Revue de géographie de Lyon,* t. XXVI, p. 367-374, 1951) et qu'aucune mention ne soit faite de la réponse d'E. de Vaumas, *A propos de l'article de M. Dubertret sur la structure du Proche-Orient d'après E. de Vaumas* (*Revue de géographie de Lyon,* t. XXVIII, p. 159-163, 1953).

L'oubli est maladroit.

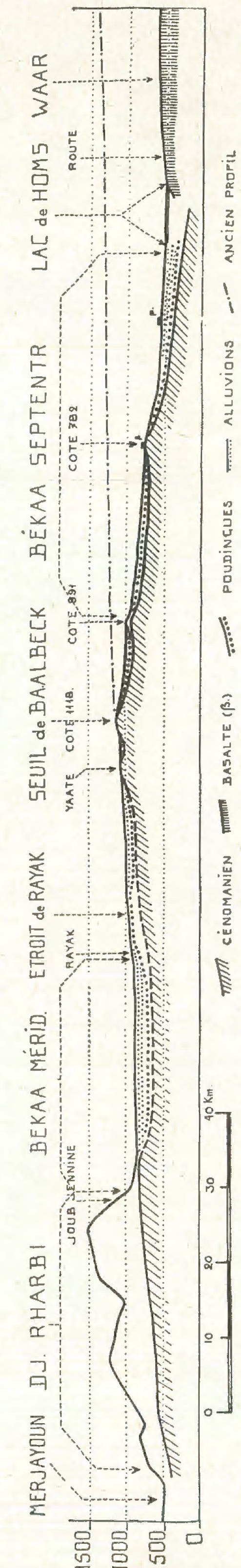


Fig. 3. Profil longitudinal de la Bekaa.

crétacé qui se trouve dans l'axe de la Bekaa montre le contact Turonien-Sénonien à 1050 m. Un autre affleurement près du village de Makné (N. de Baalbeck) le voit s'élever à 1118 m. Tous les deux se trouvent sur la ligne de partage des eaux et prouvent par conséquent que le contact du Cénomanien ou du Turonien avec le Sénonien se relève non seulement du Merjayoun jusqu'à Joub Jennine mais encore de Joub Jennine jusqu'au seuil de Baalbeck, même s'il existe entre ces deux points un ombilic sur lequel on reviendra.

— En continuant à progresser le long de la Bekaa, on trouve à nouveau au Sud du village de Laboué, un affleurement sénonien à 991 m. ce qui donne une côte plus faible encore pour le contact avec le Cénomanien.

— A l'Est de Hermel, ce contact Turonien-Sénonien se montre encore une fois à 782 m.

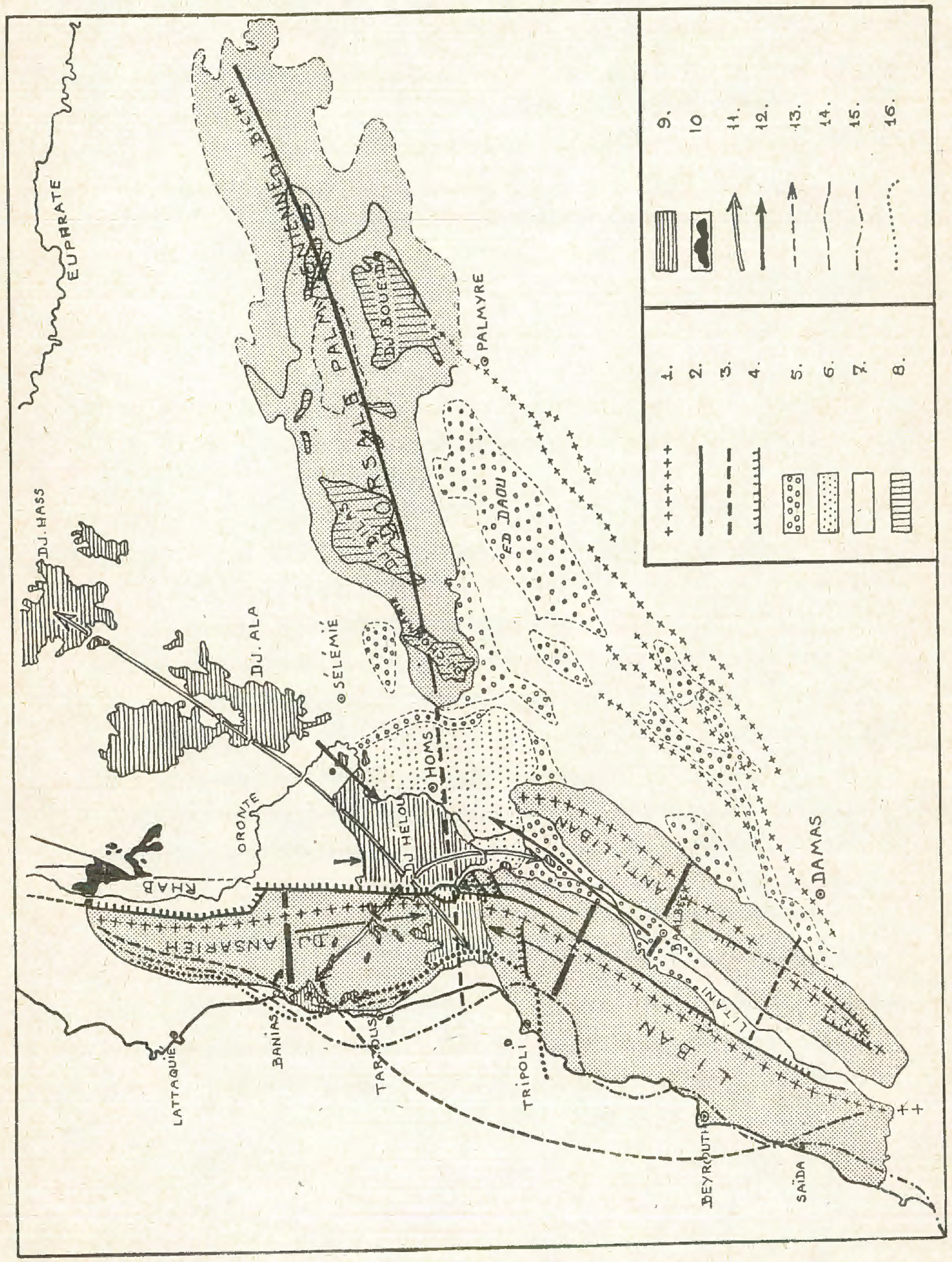
Il ne fait donc aucun doute que la surface de base du Sénonien descend à partir de Baalbeck jusqu'au bassin de Homs.

3. *Conclusions.*

Ainsi donc, le seuil de Baalbeck apparaît contre toute attente non seulement comme le point le plus élevé de la topographie mais encore comme une culmination transversale de la structure de part et d'autre de laquelle les couches s'inclinent en direction du Merjayoun et du bassin de Homs.

Par ailleurs, cette culmination ne se fait sentir, que dans le fond du berceau synclinal puisque du côté des avant-monts libanais, elle est encadrée par les deux avancées qui correspondent au Sannin et au Makmel. Il faut reconnaître cependant que du côté de l'Anti-Liban, elle prolonge la culmination transversale de ce massif.

Dans la partie Sud du sillon, l'inclinaison générale de la structure depuis le seuil de Baalbeck jusqu'au Merjayoun est affectée à hauteur de la Bekaa méridionale d'un ombilic très marqué. Le remblaiement alluvial qui va jusqu'à border le Liban et l'Anti-Liban, la disparition sous les alluvions, des poudingues néogènes du Nord, de tout le Djebel Rharbi au Sud, l'effacement du crêt nummulitique lui-même le long



1. Axe anticlinal.
2. Axe de la dorsale palmyrénienne, ou culminations transversales.
3. Axe de l'ensellement Homs-Tripoli.
4. Faille.
5. Néogène continental.
6. Alluvions.
7. Massifs montagneux et dorsale palmyrénienne.
8. Noyaux cénomaniens de la dorsale palmyrénienne.
9. Basalte pliocène.
10. Basalte quaternaire.
11. Sens des coulées basaltiques.
12. Pendage de la surface pontienne.
13. Inclinaison longitudinale des terrasses marines de Tartons.
14. Rivage nummulitique et, dans la dorsale palmyrénienne, limite Numm.-Néogène.
15. Rivage vindobonien.
16. Rivage plaisancien.

Fig. 4. Croquis structural du seuil Homs-Tripoli.

de l'Anti-Liban à l'endroit où passe la route Beyrouth-Damas, prouvent suffisamment que le profil longitudinal subit là un enfoncement très net. Il est très symptomatique de constater que l'axe transversal de cet ombilic continue exactement vers l'Ouest le grand ensellement du Barada qui sépare l'Anti-Liban et l'Hermon.

La morphologie et le réseau hydrographique de la Bekaa sont donc en conformité avec la structure et le problème que posait le profil longitudinal semble s'évanouir. Il disparaît effectivement à ne considérer que les faits actuels. Les conclusions auxquelles on est parvenu plus haut au sujet de la subsidence récente du seuil Homs-Tripoli obligent de poser à nouveau la question de savoir comment la structure présente de la Bekaa a pu se former.

III. L'Évolution structurale de la Bekaa depuis la dernière phase orogénique

La subsidence de l'extrémité de la Bekaa septentrionale est certaine. Les basaltes plaisanciens en provenance du Djebel Helou y sont entrés en effet en s'écoulant du Nord au Sud alors que leur surface de base est inclinée maintenant en sens inverse. La subsidence du Djebel Helou et de la région de Homs s'est donc répercutée dans la structure de la Bekaa.

Le problème est de savoir s'il est possible d'envisager que cette subsidence s'est fait ressentir aussi loin que Baalbeck. Pour le résoudre, il faut essayer de reconstituer le relief qui existait au moment du paroxysme orogénique plaisancien et des grands épanchements volcaniques.

1. *La dorsale du Djebel Helou.*

On a vu plus haut que la surface pontienne plonge de toute part sous le Djebel Helou et que la subsidence y atteint au minimum 865 m., en réalité un chiffre très supérieur. On a vu également que l'épaisseur des basaltes au Djebel Helou se montait à 1225 m.[1].

[1] Voir *supra*, p. 217-218.

L'attitude du Djebel Helou au moment du paroxysme orogénique était donc beaucoup plus grande et devait se situer dans les 2000-2500 m. Cette montagne et le soulèvement limitrophe qui l'accompagnait, barraient donc complètement la Bekaa vers le Nord. Ils formaient une dorsale qui prolongeait la dorsale palmyrénienne.

Celle-ci que nous avons décrite antérieurement mais de manière insuffisante sous le nom de faisceau septentrional des plis palmyréniens[1] n'est pas seulement en effet une suite de dômes allongés d'Ouest en Est (Djebel Choumarié, Djebel Bilas, Djebel Boueïda, Djebel Bichri), c'est aussi un haut fond qui fait affleurer le Crétaté, puis le Nummulitique (Djebel Bichri) au-dessus de terrains plus jeunes. Les dômes n'en sont que des accidents locaux.

Le raccord exact de la dorsale palmyrénienne avec les structures de l'Ouest est difficile à préciser. Deux hypothèses sont possibles : la dorsale palmyrénienne prolongeait celle du Djebel Helou et par delà celle-ci la culmination transversale de l'anticlinal Liban-Djebel Ansarieh qui s'est abaissée par la suite jusqu'à donner le seuil Homs-Tripoli ; — ou bien elle faisait suite à l'Anti-Liban dont elle ne serait, après une inflexion vers l'E.-N.-E., que la suite en direction de l'Euphrate ; dans ce cas, la dorsale palmyrénienne serait un pli longitudinal de direction taurique.

Ce problème structural ne peut pas être résolu pour le moment et il suffit simplement de le signaler.

Sous l'angle topographique, les choses sont beaucoup plus claires. La canalisation des laves en direction du N.-E. (Alep) et de la Bekaa, leur absence d'écoulement par la trouée qui existe entre la dorsale palmyrénienne et l'Anti-Liban, montrent suffisamment que le Djebel Helou était un nœud orographique où se rejoignaient les reliefs du Liban, de l'Anti-Liban et de la dorsale palmyrénienne. La Bekaa était absolument fermée au Nord.

2. *L'ancien profil longitudinal de la Bekaa* (fig. 3).

Dans ces conditions, son ancien profil longitudinal est facile à restituer. La dorsale du Djebel Helou se trouvant dans les 2000 m.

[1] 20.

d'altitude, toute la dépression s'inclinait de là en direction de Baalbeck puis du Djebel Rharbi. La Bekaa en son entier avait une pente du Nord au Sud. La ligne de partage des eaux était à hauteur de Homs et le Litani drainait tout le sillon.

3. *Les répercussions de la subsidence du seuil Homs-Tripoli sur la Bekaa.*

Le relâchement des forces orogéniques ont provoqué à la fin du Pliocène-début du Quaternaire une subsidence du seuil Homs-Tripoli qui s'était déjà produite une première fois durant le Pontien. Les effets de cette subsidence ont été divers selon les lieux et surtout de part et d'autre de la fracture libano-syrienne.

Dans le bloc côtier, elle a amené une plongée brusque du Liban, plongée qui se fait en quelque 25 km. et qui est précipitée par la faille de l'Ouadi Gehennam. Au Djebel Ansarieh au contraire, elle a abaissé le profil longitudinal sur une soixantaine de kilomètres de telle sorte que ce n'est pas seulement le Djebel Ansarieh méridional mais aussi le Djebel Ansarieh central qui s'abaisse vers le Nahr el Kebir.

Du côté du socle, il est difficile de préciser en direction du Nord les régions affectées. Il semble bien cependant que le relèvement de la surface pontienne s'arrête au plateau de Massiaf et à hauteur de Hama et qu'elle redescend au delà, la cuvette d'Acharné constituant une nouvelle subsidence.

Vers le Sud, l'ouverture de la trouée entre Anti-Liban et dorsale palmyrénienne est probablement une répercussion de l'affaissement du seuil Homs-Tripoli. Les effets de celui-ci sont certains dans la Bekaa septentrionale jusqu'à Hermel, l'inclinaison des basaltes en constituant une preuve certaine. La subsidence s'est fait sentir surtout sur le fond de la dépression et relativement peu sur ses bords puisque le Djebel Akroum demeure en forte saillie au-dessus des plateaux d'Akkar et du seuil lui-même. De Hermel, elle a gagné de proche en proche jusqu'à Baalbeck qui est le point extrême où s'est faite sentir son influence, entraînant un déplacement progressif de la ligne de partage des eaux vers le Sud.

IV. Conclusions et hypotheses.

L'ouverture du seuil Homs-Tripoli et ses répercussions sur les régions avoisinantes attirent l'attention sur la genèse d'une série d'accidents structuraux des massifs levantins qui n'ont pas fait jusqu'ici l'objet de recherches, ni de descriptions.

L'existence d'ensellements de très grande ampleur — ensellement Homs-Tripoli entre Liban et Djebel Ansarieh, ensellement du Qasmieh entre massif galiléen et Liban, ensellement du Barada entre Anti-Liban et Hermon, ce dernier se prolongeant par l'ombilic de la Bekaa méridionale, ensellement de Hassié entre dorsale palmyrénienne et Anti-Liban — est une caractéristique essentielle de la structure du Proche-Orient.

L'histoire de celui de Homs-Tripoli montre que celui-ci n'est pas une résultante des mouvements orogéniques qui ont donné naissance aux plissements. Il doit au contraire son origine à une subsidence qui a joué dans les phases de détente de l'orogénèse.

S'agit-il d'un cas particulier ou bien cette explication est-elle valable dans les autres cas?

L'exemple de l'ombilic de la Bekaa méridionale donne à penser que cette seconde hypothèse est la bonne. Il interrompt la pente générale de la Bekaa vers le Sud en y créant une contre-pente aux approches du Djebel Rharbi. Il n'a pas empêché cependant le Litani de continuer à s'écouler dans sa direction primitive d'où l'on peut inférer que c'est un accident local récent. Ne faut-il pas y voir aussi une subsidence post-orogénique qui expliquerait aussi — sinon complètement au moins en partie — l'énorme trouée structurale du Barada et même la cuvette de Damas.

Une explication semblable n'est-elle pas aussi valable pour la cuvette d'Acharné. Entre le plateau de Massiaf et le Djebel Zaouiyé, celle-ci manifeste un ample ensellement de la surface d'érosion polycyclique que l'Oronte utilise pour gagner le Rhâb alors que la direction primitive de ce fleuve paraît avoir été vers le N.-E. C'est cette direction qu'il prend en effet d'abord jusqu'aux environs de Hama et qu'il devait

suivre vraisemblablement par la suite. La traînée de basalte qui va jusqu'à Alep indique en effet probablement la ligne des points bas de la topographie plaisancienne. Il se jetait alors, soit dans l'Euphrate qui est dans cette direction, soit dans l'Amouk au cas où la trouée entre Djebel Akra et Kurd Dagh existait déjà.

Ces dernières considérations sont encore pleines d'incertitudes et ne font qu'amorcer des recherches ultérieures.

Elles n'ont d'autres buts pour l'instant que de montrer que l'histoire des nombreux seuils des massifs levantins est à faire et qu'on ne saurait la négliger. La reconstitution de celle du seuil Homs-Tripoli est assez riche d'enseignements touchant la structure et la morphologie pour qu'elle s'impose désormais.

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CARTOGRAPHIE

I. Cartographie topographique.

1. Carte au 1/200.000e.
   Feuilles de : Lattaquié-Tripoli-Homs.

2. Carte au 1/50.000e.

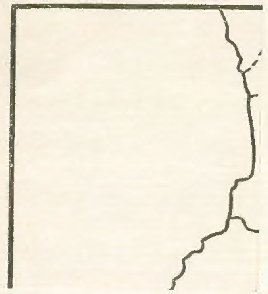
Feuilles de :

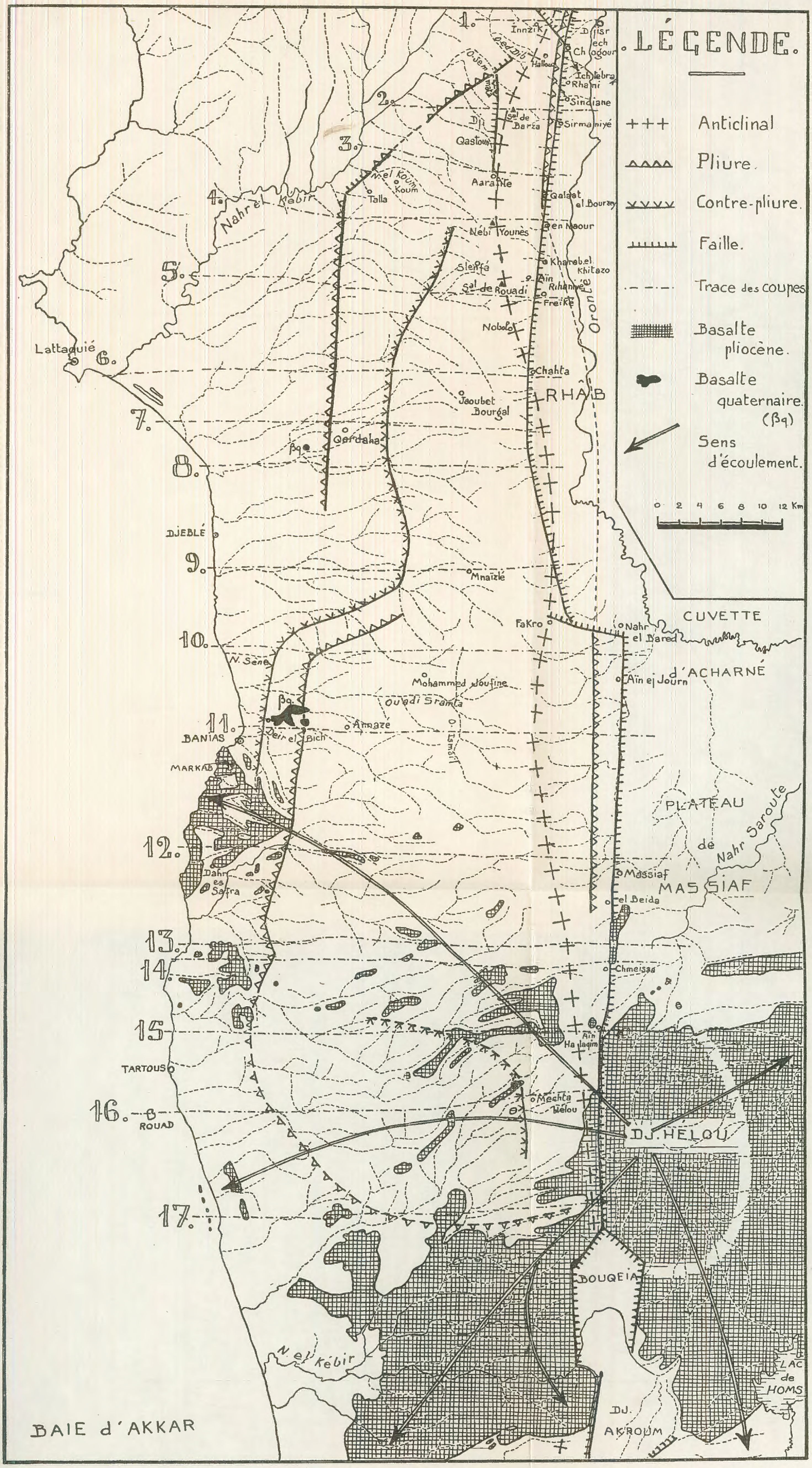
Kessab, Ordou, Djisr ech Choghour, Lattaquié, Haffé, Rhâb-Nord, Djeblé, Qerdaha, Rhâb-Sud, Banias, Qadmous, Massiaf, Tartous, (Safita), (Qalaat el Hosn), Hamidié, Halba, Tell Kelakh.

N. B. Toutes les feuilles sont parues, sauf celles de Safita et de Qalaat el Hosn pour le territoire desquelles on ne possède que le 1/200.000e.

II. Cartographie géologique.

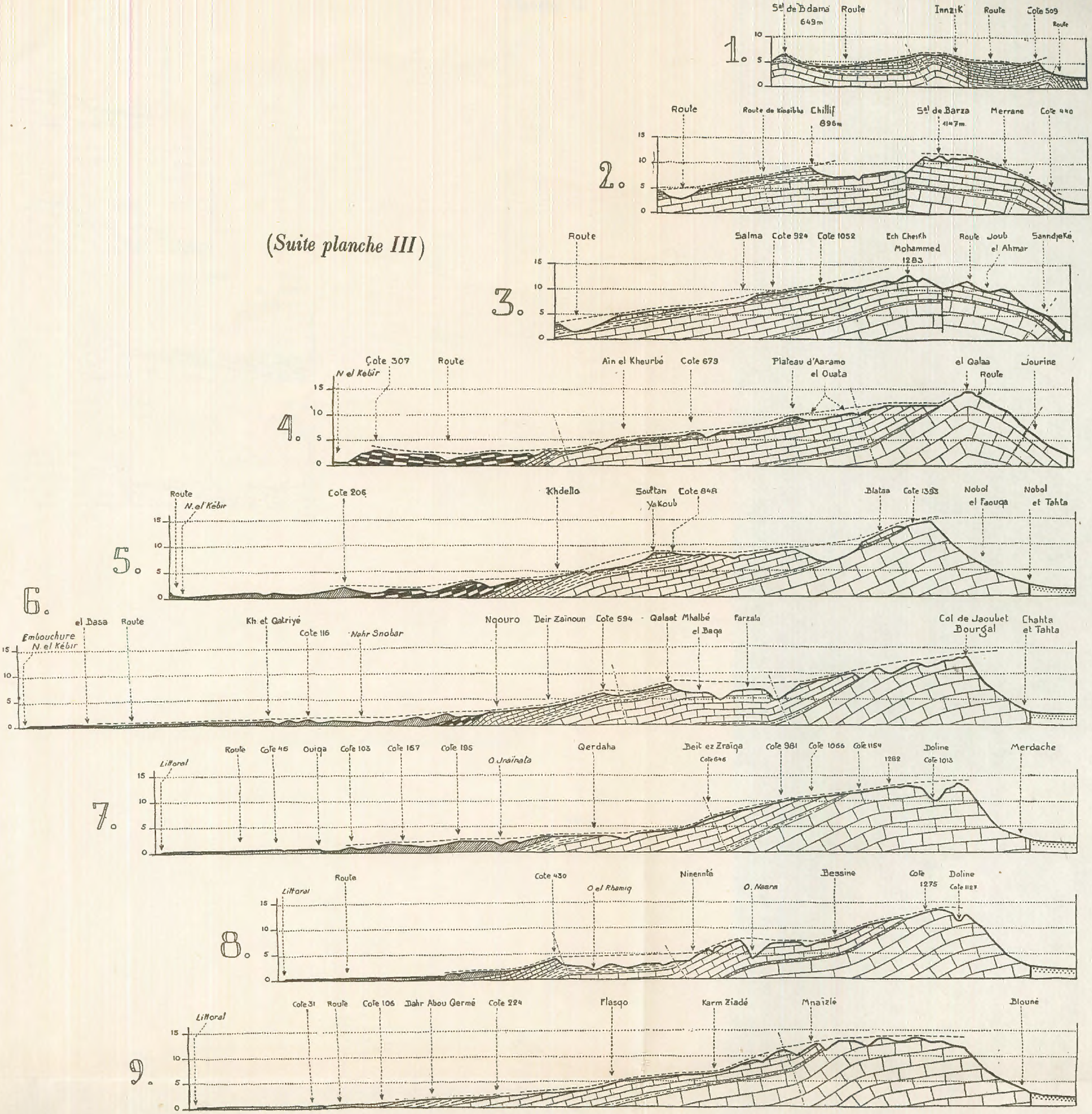
1. Carte géologique de la Syrie et du Liban au millionième (2e éd.). Voir : 14.
2. Carte lithologique de la bordure orientale de la Méditerranée en 2 feuilles au 1/500.000e. Voir : 15.
3. Carte géologique du NW de la Syrie et du Hatay (1/500.000e). Voir : 17, planche A.
4. Carte géologique du Bassit, du Baer et des environs du Djebel Akra au 1/200.000e. Voir : 17, planche B.
5. Carte géologique au 1/50.000e. Feuilles de Tartous et d'Hamidiyé.



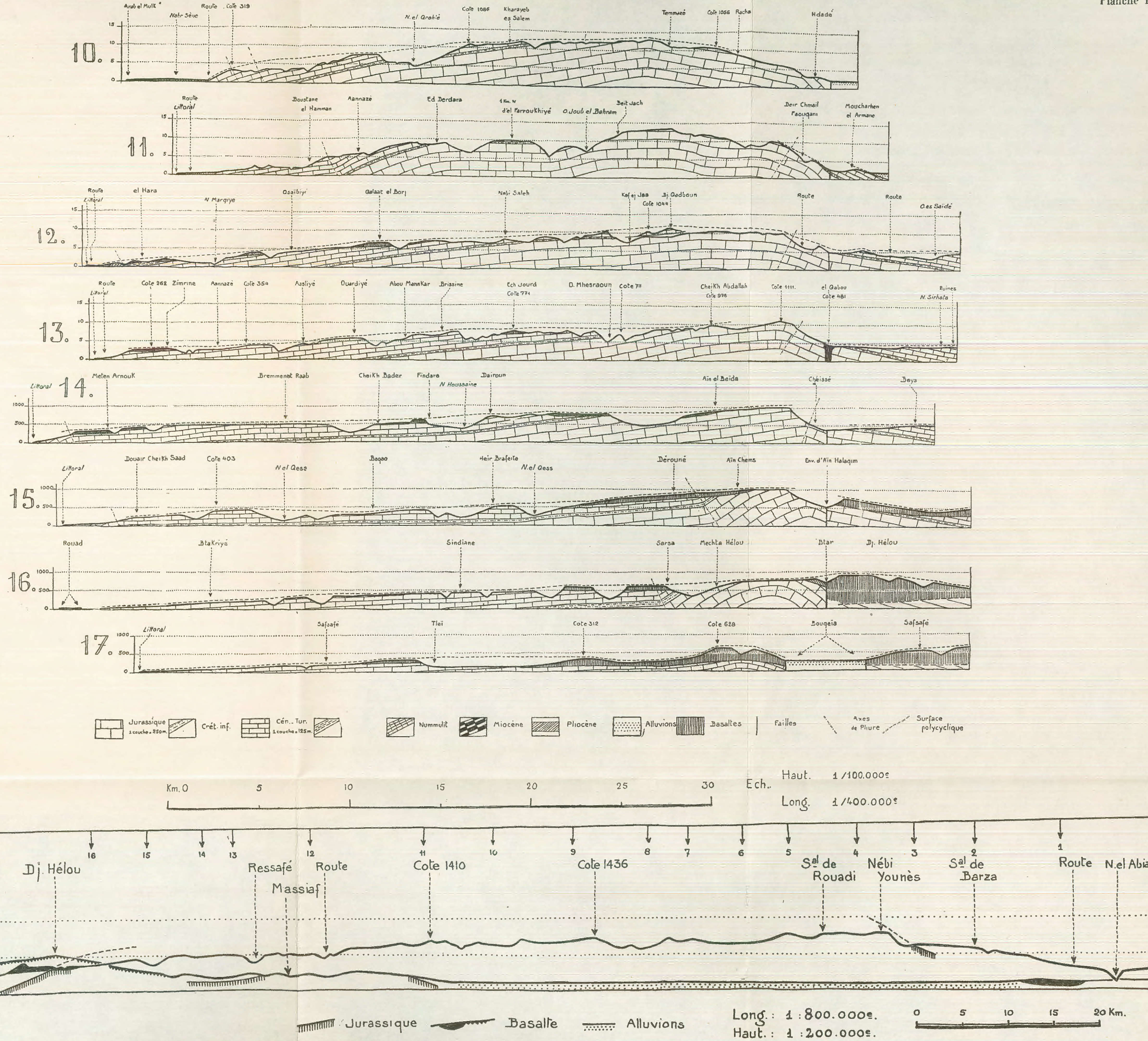


Carte structurale du Djebel Ansarieh.
Les tiretés numérotés indiquent les traces des coupes (planches II et III).
(Echelle : 1/400.000^{e}).

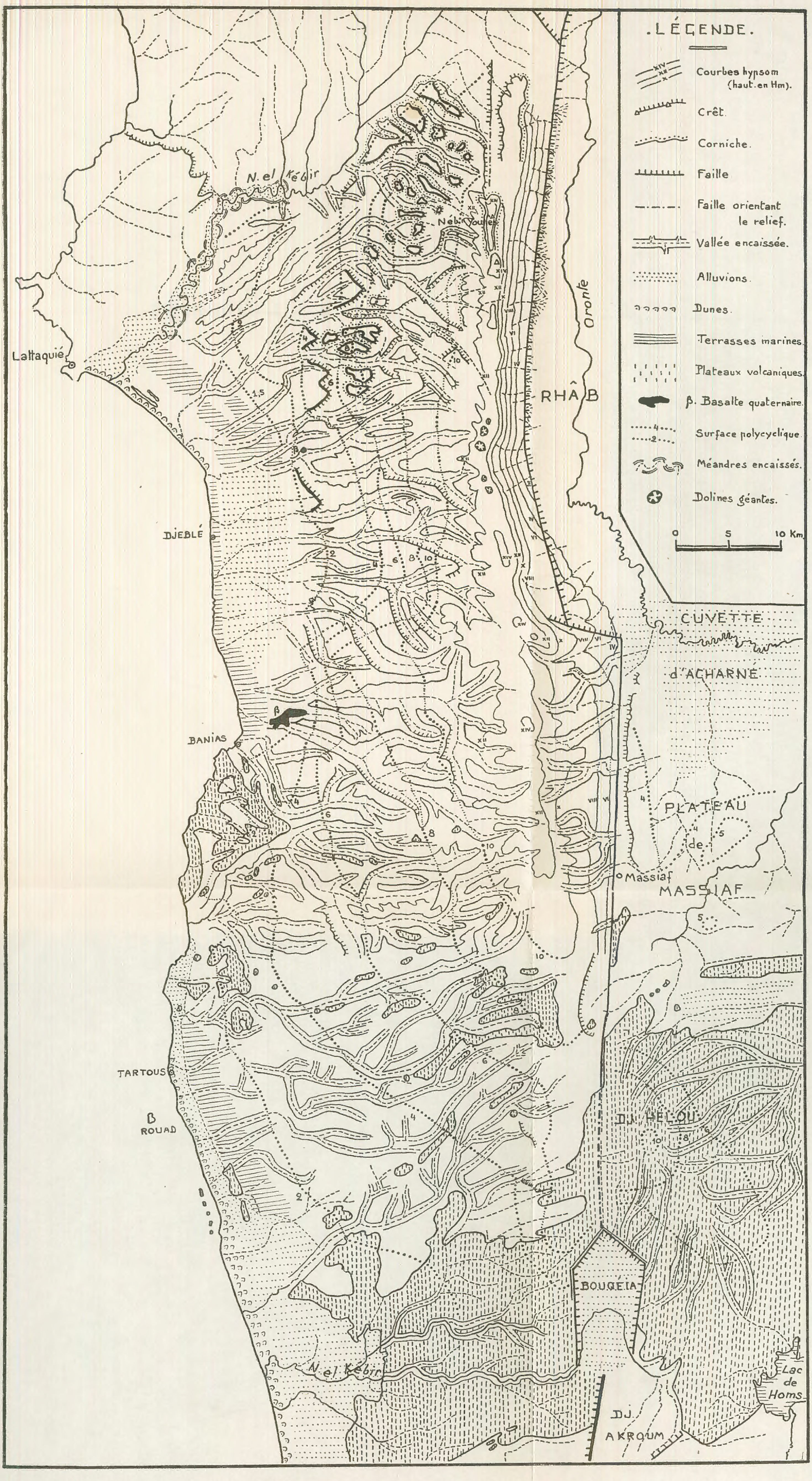
Planche II



(Suite planche III)



(Errata : Les coupes transversales ont une échelle des longueurs de 1/200.000e; la coupe longitudinale une échelle des longueurs de 1/400.000e).



Carte morphologique provisoire du Djebel Ansarieh
(Echelle : 1/400.000e).

PLANCHES 1 À 6

Photo A. *Retombée du Djebel Ansarieh à hauteur de Djisr ech Chogour.*

La vue est prise vers le Nord depuis la grande route Alep-Djisr-Lattaquié. Les couches cénomaniennes sont subhorizontales à gauche. En réalité —, du fait que la vue est panoramique et que ces couches sont vues de face sur la gauche et de profil à droite — , elles plongent déjà à gauche vers l'Ouest. A droite, elles plongent brusquement sous les marnes miocènes de la vallée de l'Oronte qui, de Djisr à l'Amouk, correspond à un grand synclinal en berceau. [Comparer avec la coupe N° 1].

Photo B. *Versant oriental du Djebel Ansarieh.*

La vue est prise vers le Sud à hauteur du village d'Aïn Sleïmo (23 km. au Sud de Djisr ech Chogour). La plongée des couches jurassiques est ici nettement visible. Au premier plan, cône de déjection. [Comparer avec la coupe N° 4].

A

B

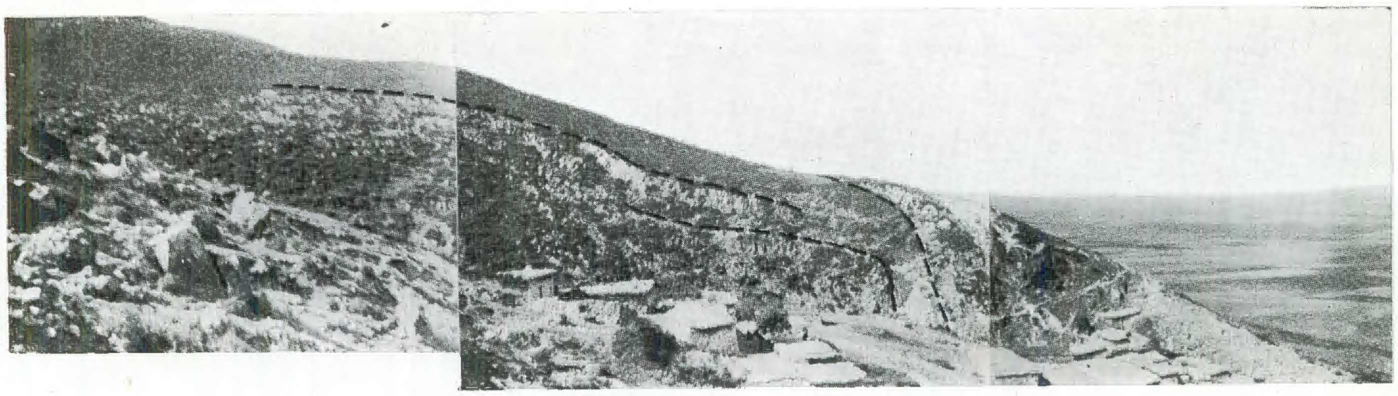
Pl. 1

Photo A. *Versant oriental du Djebel Ansarieh.*

Pliure au village de Sirmaniyé (10 km. au Sud de Djisr ech Chogour). Les couches cénomaniennes en pente lente sur la gauche ont un pendage subvertical sur la droite. A l'Est, dépression du Rhab et rebord du plateau d'Idlib. [Comparer avec la coupe N° 2].

Photo B. *Versant oriental du Djebel Ansarieh.*

Incurvation du contact du Djebel Ansarieh et du Rhab. Elle est due à l'effondrement du versant oriental de la montagne (visible au fond) sous la dépression du Rhab (ici sous les grands cônes de déjection qui font une tâche blanche.



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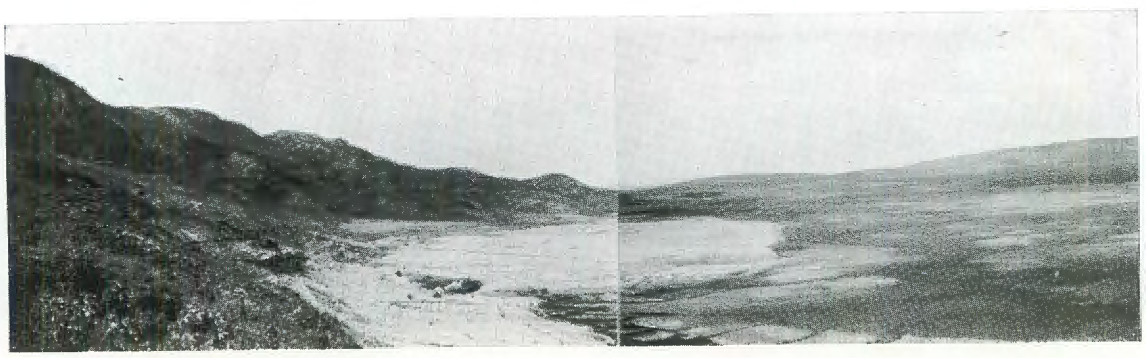


B

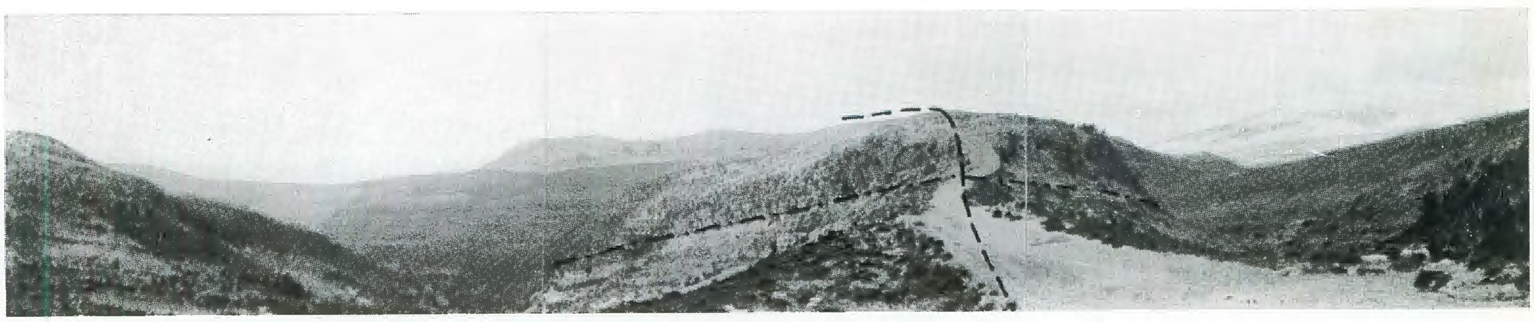
Pl. 2

Photo A. *Versant occidental du Djebel Ansarieh septentrional.*

La vue est prise vers l'Ouest, depuis la piste qui monte à Mrechté. Le crêt nummulitique est visible au fond dans l'axe de la piste (Chir el Hassane), au fond et à droite (Soultan Yakoub). La crête transversale qui suit la piste recoupe les couches cénomaniennes dont le pendage est beaucoup plus fort. Les traces de la surface d'érosion polycyclique (marquées par un tireté) se prolongent sur le revers du crêt nummulitique [Comparer avec la coupe N° 6].

Photo B. *L'Anticlinal jurassique (J) du Djebel Ansarieh septentrional.*

La vue fait face à l'Est. On voit le village de Jaoubet Bourghal (J. B.). Elle se situe sur la même transversale que la précédente. A gauche et à droite, calcaires cénomaniens qui esquissent un crêt très léger de part et d'autre de la vallée mais dont le revers est arasé (lignes de traits) et continue la surface crevée de dolines qui constitue le sommet de l'anticlinal jurassique. La ligne de points indique le contact du Crétacé et du Jurassique. La ligne de traits et de points montre que le plongement des couches de base du Cénomanien est beaucoup plus fort que celui des couches supérieures. [Comparer avec la coupe N° 6].



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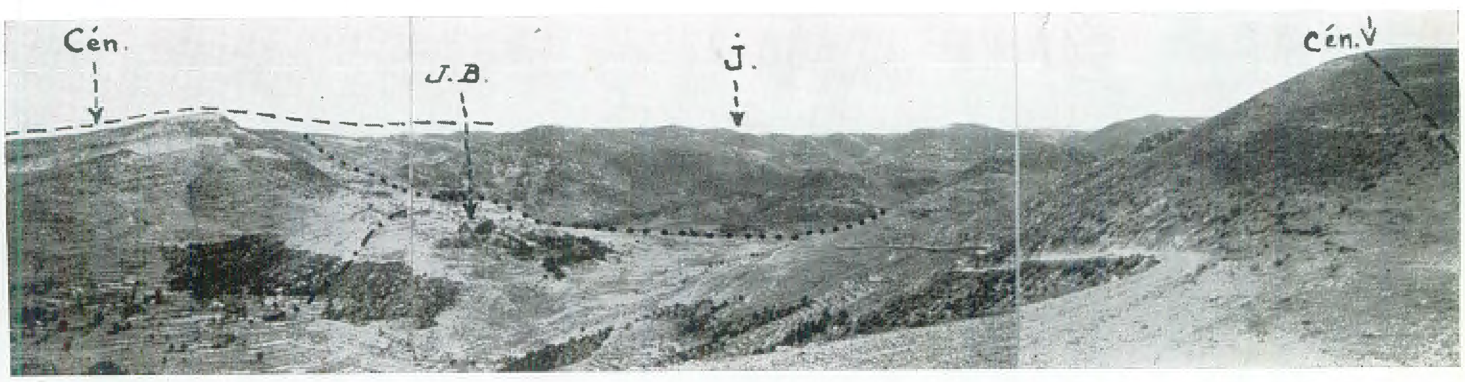


B

Pl. 3

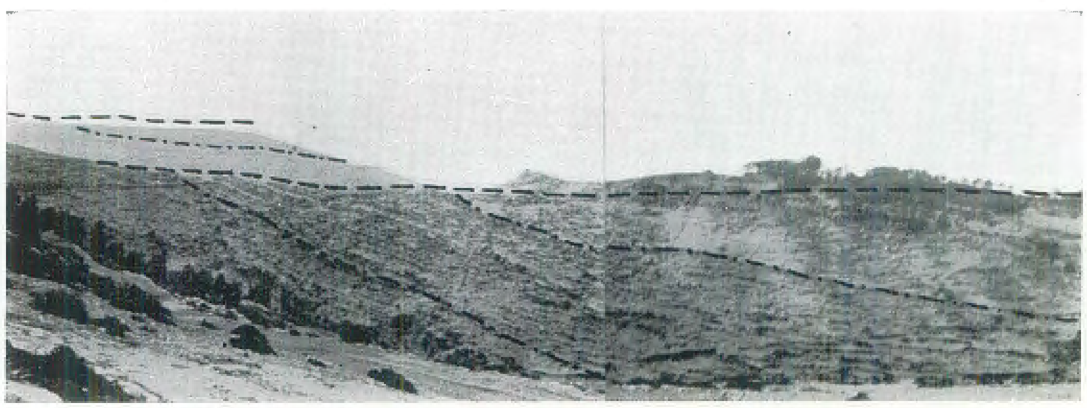
Photo A. *Versant occidental du Djebel Ansarieh septentrional.*

La vue est prise vers l'Ouest (à gauche) et le Nord-Ouest (à droite). Crêts nummulitiques du Djebel Arbein (Dj. A.), de Qalaat Melbé (Q. M.) et de Chir el Hassane (C. H.). En tiretés, le contact du Sénonien et du Nummulitique, recoupé par la surface sommitale (en traits et points). Lente montée du Cénomanien (au centre et à droite), également recoupée par la surface topographique [Comparer avec la coupe N° 6].

Photo B. *Versant occidental du Djebel Ansarieh septentrional.*

Hautes crêtes cénomaniennes, peu avant leur contact avec le Jurassique (à gauche, mais non visible). Toutes les couches dont le pendage est souligné par des lignes de traits-points sont recoupées par les sommets des crêtes, qui sont les vestiges de la surface polycyclique [Comparer avec les coupes N°s 6, 7, 8].

A



B

Pl. 4

Photo A. *Pays pliocène de Lattaquié.*

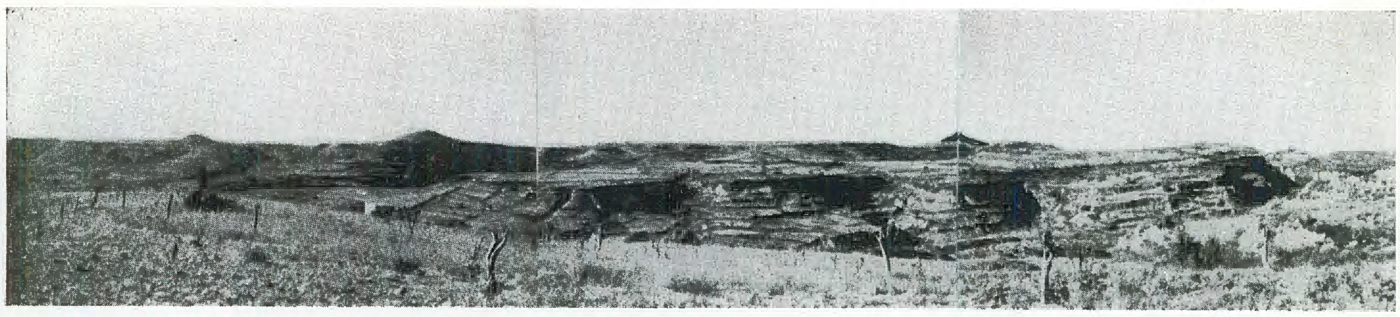
La crête du fond est la crête Bzafté-Brabichbo. Aplanissement descendant de l'Est vers l'Ouest et nivelant le Miocène à droite (roches claires) et les argiles pliocènes, plus sombres, à gauche. Des buttes résiduelles sur le sommet de la crête ont échappé au nivellement. Au fond (teintée en noire), la pyramide du Djebel Akra (Casius) [Comparer avec les coupes Nos 5, 6].

Photo B. *Pays pliocène de Lattaquié.*

Entaille du Nahr el Qalaa (la rivière du Sahyoun, la forteresse est à gauche de la photo) montrant le plongement du Cénomanien (traits et points) sous le Miocène et leur recoupement par la surface topographique. Celle-ci se prolonge plus à l'Ouest sur le Pliocène [Comparer avec la coupe N° 6].

Photo C. *Fragmentation du crêt nummulitique.*

Le crêt nummulitique (ici Chir el Hassane, voir pl. III-A et pl. IV-A) se crevasse et s'éboule sur les pentes sénoniennes (à gauche) qui sont jonchées de ses débris.



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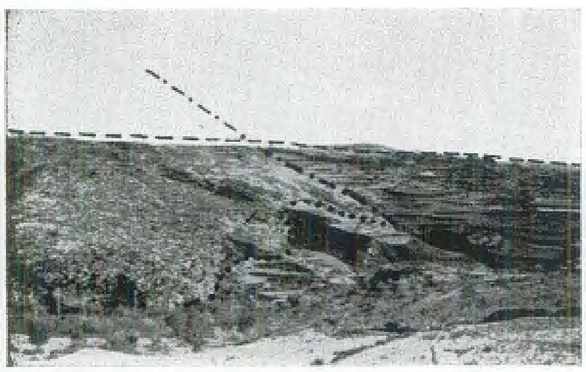


B

C

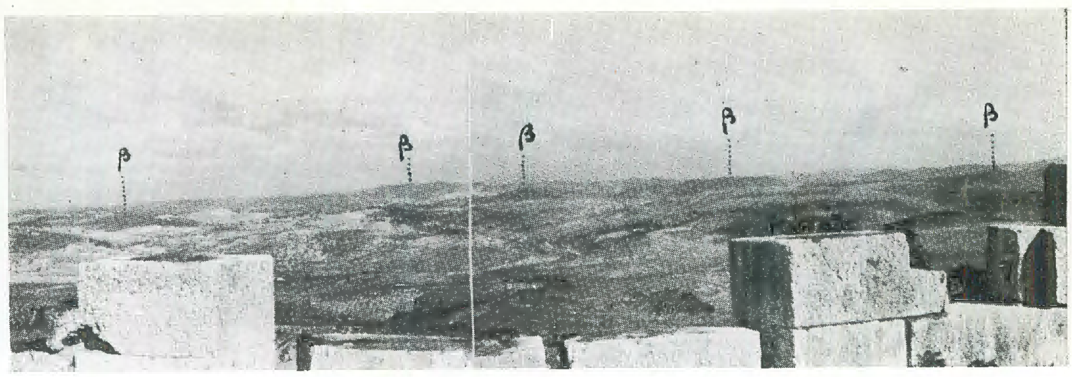
Pl. 5

Photo A. *Le Djebel Ansarieh méridional.*

La vue est prise du haut du Château de Safita vers le Nord-Est. Monotonie du paysage qui correspond à une descente lente des couches et de la surface d'érosion de l'Est vers l'Ouest. Quelques témoins de la grande nappe basaltique, conservés au sommet des crêtes ont été indiqués (β) [Comparer avec les coupes Nos 15, 16].

Photo B. *Le sommet du Djebel Ansarieh méridional.*

L'anticlinal jurassique (J.) qui forme la crête plonge brusquement vers l'Ouest par une pliure brusque (Ligne de traits-points). Le Crétacé (à droite) descend lentement vers la mer. La surface topographique s'étend indifféremment sur le Jurassique et le Crétacé comme le montre notamment une crête transversale (soulignée par un tireté). Vallée monoclinale de Mechta Helou (M. H.) dont le talweg est déjà enfoncé épigénétiquement dans le Jurassique [Comparer avec la coupe N° 16].



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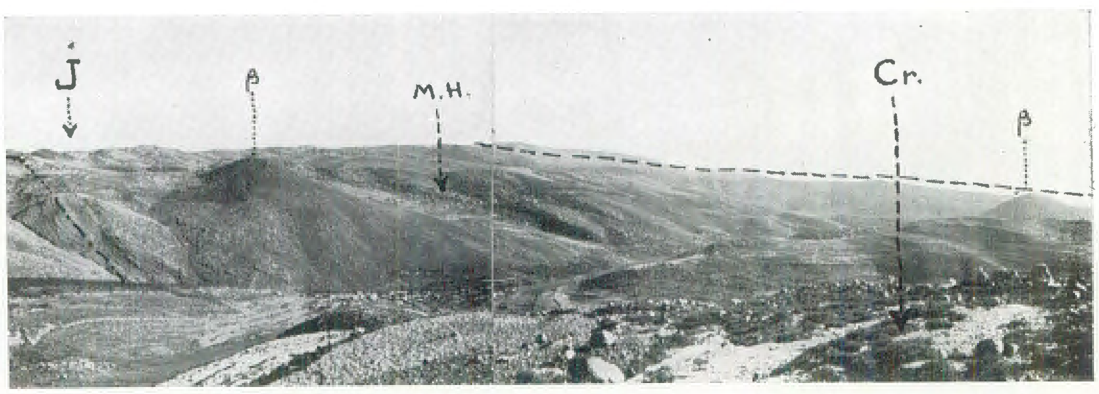

B

Pl. 6

أن تنطبق الألوان انطباقاً كاملا ، لهذا أجرت المصلحة تجارب اتضح منها إمكان الحصول على درجات مختلفة من اللون على لوحة طباعة واحدة باستعمال « شبكة » ، وأمكن بذلك توفير وقت إعداد لوحات مختلفة لدرجات اللون الواحد مما ينتظر أن يؤدى إلى زيادة كبيرة فى الإنتاج مع وفر فى نفقاته وضمان الدقة فى تطبيق الألوان إلى جانب أن لوحات الطباعة التى تعد بالطريقة المستحدثة يتم تجهيزها بطريقة آلية تتيح زيادة ملموسة فى عدد النسخ التى يمكن طبعها من كل لوحة .

الدكتورة دولت أحمد صادق — الحاجة إلى تخطيط شامل لمصر .

مصر فى مولدها الجديد القوى محتاجة إلى تخطيط وتنظيم عام يشمل :

ا — الأرض سواء من ناحية التعدين أو من الناحية الزراعية .

ب — من ناحية السكان والمشاكل المختلفة المتعلقة بازدياد عددهم وعدم تناسب هذه الزيادة مع ثروة الأرض الزراعية وإيجاد حلول مختلفة خصوصاً الاتجاه ناحية الصناعة .

ج — تصنيع مصر وهذا هو الاتجاه الحديث الذى اهتمت به حكومة الثورة وقد أنشأت وزارة للصناعة مستقلة .

وأخيراً اختتمت المقال بدراسة الدور الذى يستطيع أن يلعبه الجغرافى فى هذا التخطيط .

العناصر الحضارية التى نشأت فى أرضها أصبحت ملائمة لظروفها الطبيعية ، وكان من العبث أن ينبذها المصريون مع صلاحيتها للحياة والبقاء . وبعض العناصر دخلت من الخارج فأضافت إلى تنوع الحياة الفكر والحضارة فى مصر .

٧ — وامتازت مصر فوق ذلك بأنها أضافت إلى التراث الإنسانى الخالد عن طريق الخلق والإنشاء من جهة ، وعن طريق احتضان بعض ألوان الفكر الأخرى وحفظها على الزمن من جهة أخرى . ومن ذلك ما حدث من احتضان مصر للفكر الإغريقى فى الأسكندرية ومدرستها القديمة ، وللفكر العربى والإسلامى بالقاهرة والأزهر . وبذلك قامت حياة مصر وتاريخها الحضارى على أساس الأخذ والعطاء والاتصال والربط بين القديم والجديد وبين الشرق والغرب ، فمصر كانت كهمزة الوصل فى الفكر الإنسانى فى الزمان والمكان .

٨ — ومصر الحديثة تبنى حياتها ونهضتها المعاصرة مستندة إلى كل هذه المقومات فى البيئة وفى التاريخ . وهى تعرف أن من منابع قوتها وحدة مجتمعها المصرى الذى غالب الزمن ، كما أن من مقوماتها تلك الثروة الطبيعية التى حفظت على المصريين حياتهم وتاريخهم ، وذلك الموقع الجغرافى الفريد بين الشرق والغرب ، وتلك التقاليد التى سار عليها المصريون خلال التاريخ كله من أنهم يعيشون لأنفسهم كما يعيشون للإنسانية كلها ، ويحافظون على مكانتهم كأمة توائم فى توازن بين القديم والجديد ، وتربط فى اتساق بين الشرق والغرب ، وتقوم بدور النواة وهمزة الوصل بين مختلف أجزاء العالم العربى المحيط بها فى آسيا وأفريقية . وعلى أساس الإفادة من هذه المقومات وبعث القوة والحيوية القومية من مكانها فى البيئة المصرية وحياة المجتمع المصرى تسير مصر المعاصرة فى طريقها المرسوم لتجديد حياتها واستعادة مكانتها التاريخية وأداء رسالتها نحو الإنسانية جمعاء .

الدكتور محمد محمود الصياد — موارد الغذاء ونمو السكان فى مصر .

دلت الدراسات على أن هناك انحطاطاً مستمراً فى مستوى التغذية وبخاصة عند الفلاحين . ولعلاج هذه المشكلة كان لا بد من التوسع فى إنتاج المواد الغذائية ولذلك ثلاثة طرق هى :

١ — توسيع رقعة الأراضى الزراعية وذلك بتحويل ما بقى من أراضى الحياض إلى الرى الدائم . وسيلعب السد العالى دوراً خطيراً فى هذا الموضوع إذ سيوفر الماء لنحو مليونى فدان ، والكهرباء الرخيصة لرفع المياه لرى أربعة ملايين فدان فى الصحارى المصرية .

٢ — تنويع الغلات الزراعية فبالرغم من أن الحاصلات الغذائية تشغل نحو ٤٦ فى المائة من مساحة الزراعات فلا تزال مصر تستورد بعض المواد الغذائية من الخارج ولا بد من إعادة النظر فى أنواع الغلات الزراعية بحيث يتوسع فى زراعة الأنواع التى تعطى طاقة حرارية أعلى كما تجب العناية بالثروة الحيوانية ومنتجاتها .

٣ — تحسين الإنتاج ، باستخدام البذور المنتقاة ، وتوفير البيئة الملائمة لكل غلة ، ووقاية المزروعات من الآفات والأمراض ، ثم بتخفيض تكاليف الإنتاج .

ولكن مهما يكن من أمر فالتصنيع ضرورة لازمة لمواجهة مشكلة تزايد السكان فى مصر .

الأستاذ المهندس محمد أحمد عتيبة و(المرحوم) المهندس على فائق صلاح — تطور طرق طباعة الخرائط بمصلحة المساحة .

توجد ثلاث طرق رئيسية لطبع الخرائط :

١ — بجعل الرسم بارزاً عن سطح لوحة الطباعة كما فى حالة الكليشيهات .

٢ — بجعل الرسم محفوراً فى سطح لوحة الطباعة كما فى حالة الفوتوجارفير .

٣ — بجعل الرسم فى مستوى سطح لوحة الطباعة ولكن طبيعته تختلف عن سائر سطح اللوحة بحيث يلتصق حبر الطباعة بتفاصيل الرسم دون باقى اللوحة عند مرور اسطوانة الحبر عليها كما فى حالة الليتوجرافى .

والطريقة الأخيرة هى المستعملة غالباً فى طباعة الخرائط والمعتاد أن تخصص لوحة طباعة لكل درجة من كل لون ونظراً لأن إعداد هذه اللوحات يستنفد جهداً كبيراً ويستغرق وقتاً طويلا كما أنه كثيراً ما يقتضى الأمر إعادة الطبع حتى يمكن

طريق الكورنيش أيضاً الذى يمتد من كوبرى الجيزة إلى امبابة ومنها إلى مديرية التحرير .

أما المدخل الشمالى فيدخل القاهرة عن طريق معبر صغير يعرف باسم كوبرى شبرا ويتصل بشارع شبرا وهو طريق مزدحم للغاية يخدم حوالى ثلث مليون نسمة من سكان حى شبرا وروض الفرج ولتحسين هذا المدخل مد طريق الكورنيش من القناطر على طول ضفة النيل إلى حلوان وبذلك خف العبء عن طريق شارع شبرا .

والمدخل الثالث هو امتداد طريق الأسكندرية — القاهرة الصحراوى ويدخل القاهرة بالقرب من أهرام الجيزة وبذلك يبعد مسافة طويلة عن قلب القاهرة ولتحسين هذا المدخل يمكن أن يدخل القاهرة عن طريق مدينة الأوقاف ثم كوبرى الزمالك أو عن طريق الدقى وكوبرى الجلاء وبذلك تقصر المسافة بين الطريق الرئيسى ووسط القاهرة .

والمدخل الرابع عن طريق القاهرة — السويس وبدلا من اتصاله بوسط القاهرة عن طريق مصر الجديدة ومحطة مصر يمكن أن يصل إلى قلب القاهرة بطريق يمتد على طول سفح جبل المقطم حتى حلوان وسيخدم هذا الطريق خاصة المصانع الحربية بين حلوان والمعصرة خصوصاً بعد أن أصبحت قناة السويس قاعدة حربية صناعية مصرية .

الدكتور سليمان حزين — الأسس والمقومات الجغرافية للنهضة القومية المعاصرة فى مصر .

هذا بحث يستعرض الأسس والمقومات الجغرافية للنهضة القومية المعاصرة فى مصر ، ويلقى نظرة إلى المستقبل فى ضوء ما نعلمه من تاريخ مصر الطويل .

ويمكن تلخيص أهم نقط البحث فيما يلى :

١ — قال هيرودوت إن مصر هبة النيل . ومع أن هذه العبارة صحيحة فى جملتها فان الحقيقة أن حياة مصر وحضارتها جاءتا نتيجة لتفاعل عاملين : هما البيئة الجغرافية الصالحة والمجهود البشرى المتصل .

٢ — يعتبر نهر النيل ومجراه ظاهرة جغرافية حديثة نسبياً من الناحية الجيولوجية . ولكن هذا الوادى كان مع ذلك وطناً لحضارة من أعرق الحضارات البشرية وأقدمها ؛ والسبب الأول فى ذلك أن التطور الجيولوجى لنهر النيل ذاته مساعد على تكوين التربة الخصبة فوق طبقات من الحصى والحصباء والرمال ، فساعد ذلك على تصريف المياه الجوفية وصرف المستنقعات وصلاحية أرض الكنانة للزراعة والاستقرار .

٣ — ثم جاءت جهود المصريين فى الأرض الطيبة منذ العصر الحجرى الحديث وخلال عصر ما قبل الأسرات حين تعلم المصريون الوحدة والنظام ؛ ذلك أن الزراعة المصرية كانت من النوع الذى يعتمد على الرى ، وهذا يستلزم تقسيم الأرض إلى حياض كما يستلزم شق الترع والقنوات ، وهى كلها تحتاج إلى توحيد جهود الجماعة وتنظيمها ، فضلا عن أن خطر الفيضان السنوى استلزم أيضاً تضافر الجماعة . فالوحدة فى مصر جاءت ضرورية لدفع الخطر المشترك كما كانت أساساً لجلب المنفعة المشتركة .

٤ — كذلك كان للصحارى دورها الخاص فى حياة مصر وتاريخها ؛ فقد كانت بمثابة الدروع التى تقى مصر وتحفظ عليها شخصيتها ، وهى وإن لم تكن قد قطعت صلات مصر بالخارج ، فانها قد نظمت تلك الصلات . وكانت صحارى مصر من النوع الجاف فلم تسكنها قبائل كثيرة تطغى على الأرض المستقرة بين حين وآخر ، وتغير معالم حياتها المستقرة وطابعها الزراعى ، كما حدث فى العراق أكثر من مرة .

٥ — كما كان لموقع مصر الجغرافى أثره الظاهر فى تاريخها العام . ولكن قيمة ذلك الموقع العالمية لم تظهر إلا بعد عهد الاسكندر الذى كان أول من قام بحرب عالمية بالمعنى الصحيح للكلمة . وقد ترتب على ظهور فكرة العالمية بعد عهد الاسكندر أن برزت قيمة موقع مصر الجغرافى كعامل موجه فى تاريخها العام ؛ فبعد أن كانت مصر سيدة تاريخها المطلقة فى العهد الفرعونى دخلت عناصر أجنبية وجهت تاريخ هذه البلاد فى بعض الفترات .

٦ — ولكن حياة مصر رغم ذلك احتفظت بظاهرتين هما الاستقرار والتجدد . وقد يبدو أن الاستمرار كان يمثل نوعاً من الجمود ، ولكن الذى يدرس تاريخ مصر الحضارى والثقافى لا يلبث أن تبهره الحقيقة الواضحة وهى أن مصر استطاعت أن تلائم فى حياتها وحضارتها بين القديم والجديد وبين الماضى والحاضر ؛ فبعض

هـ — الذبذبات المناخية الحديثة التى ظهرت فى الألف سنة الأخيرة ، وقد كان المناخ فى أولها يميل للبرودة ، وفى آخرها يميل إلى الاعتدال وهذا هو ما يوجد فى الوقت الحاضر .

والنظريات التى حاولت تفسير التغيرات المناخية خصوصاً ما يتعلق منها بالذبذبات الحديثة كثيرة ، إلا أن النظرية التى لاقت قبولا ظاهراً فى الوقت الحاضر هى النظرية التى اقترحها ديفانت Defant فى سنة ١٩٢١ ، وملخصها هو أن التغيرات المناخية ترجع إلى حدوث تغيرات فى نشاط الدورة الهوائية العامة ؛ وقد لاقت هذه النظرية قبولا ظاهراً من كثير من الباحثين خصوصاً فيما يتعلق بتفسير فترة الدفء التى تمر بشمال غرب أوربا فى الوقت الحاضر ؛ ويعتبر Eriksson من أكبر أنصار هذه النظرية ، وهو يرى أن فترة الدفء هذه سببها هو اشتداد تدرج الضغط الجوى فى هذه المناطق بصفة عامة ، مما أدى إلى وصول كثير من الهواء الدافىء نحوها من العروض الدافئة .

أما فيما يتعلق بالتغيرات المناخية التى سبقت هذه الفترة فليس من السهل تحديد سبب واحد لها ، وإننا نفضل أن ندرس كلا منها على حدة ونبحث عن العوامل التى أدت إليها ، فقد تبين من الدراسات المختلفة أن العامل الواحد قد لا يظهر أثره فى جميع الفترات ، كما أن الفترة الواحدة قد يظهر خلالها تأثير أكثر من عامل واحد ؛ فمن المرجح مثلا كما يرى بروكس أن فترة المناخ القارى التى أعقبت العصر الجليدى كان لها سببان هما : ١ — ازدياد ميل محور الأرض . ٢ — خروج الكرة الأرضية من الوضع الذى كان فيه نصفها الشمالى أبعد ما يكون عن الشمس ؛ ..... أما الفترة الدافئة الممطرة التى أتت بعد ذلك فيرجح چورچ سيمسون G. Simpson أن سببها هو ازدياد الإشعاع الشمسى مما أدى إلى ارتفاع درجة الحرارة وزيادة تبخر المياه .

أما الذبذبات المناخية التى أعقبت هذه الفترة فربما كان سببها هو اندفاع بعض الكتل الجليدية من المنطقة القطبية نحو العروض السفلى فى بعض الأزمنة نتيجة لحدوث اضطرابات جوية ؛ وقد ساعدت هذه الكتل على كثرة العواصف والأمطار .

أما التغيرات الحديثة التى ظهرت خلال القرنين الأخيرين ولا تزال موجودة حتى الآن فمن الممكن تفسيرها على أساس نظرية ديفانت التى سبق أن أشرنا إليها .

الأستاذ نصرى شكرى والدكتور مصطفى كمال العيوطى — جيولوجية منطقة جبل عويبد وجبل الجفرة بين القاهرة والسويس .

درس المؤلفان بشىء من التفصيل جيولوجية منطقة جبل عويبد وجبل الجفرة بين القاهرة والسويس ، والتى تبلغ مساحتها حوالى ٣٠٠ كيلومتر مربع وقد رسما لها خريطة جيولوجية مفصلة على مقياس ١ — ٢٥,٠٠٠ .

وناقش المؤلفان تتابع الصخور على السطح وتحت السطح فى المنطقة والتراكيب الجيولوجية الموجودة بها من ثنيات وفوالق ، كما درسا التاريخ الجيولوجى واحتمالات وجود البترول فيها .

الدكتور ا . ريتمان — الخطوط الرئيسية لنظرية جيولوجية جديدة .

أبرز الكاتب شدة الحاجة لنظرية جيولوجية شاملة ، واستعرض النظريات الجيولوجية السابقة ، ثم انتقل إلى نظريته التى سبق أن تعرض لها فى كتاباته منذ عام ١٩٤٣ وأساسها أن كل حادث جيولوجى إنما هو رد فعل يهدف إلى إعادة توازن ستاتيكى أو ديناميكى سبق أن أصابه الاختلال . ومضى المؤلف فى شرح الخطوط الرئيسية لهذه النظرية الجديدة .

الدكتورة دولت أحمد صادق — مداخل القاهرة الرئيسية .

اتسعت مساحة مدينة القاهرة الحالية اتساعاً كبيراً حددته الظروف الطبيعية المحيطة بها ولم تعد مداخل القاهرة القديمة تكفى حاجتها وتكفى حاجة سكانها الآخذ عددهم فى الازدياد ولذلك قامت حكومة الثورة بتوسيع مداخلها القديمة وتحسينها .

فالمدخل الجنوبى يسير موازياً لسكة حديد الوجه القبلى ويدخل القاهرة بالقرب من نفق شارع الهرم وهذا المدخل لا يتفق الآن مع مركز القاهرة الحالى . ولتحسينه يجب أن يكون هناك طريق من كوبرى الجيزة إلى بندر الجيزة حتى ساقية مكى وبذلك يتفادى المرور نهاية ترام الجيزة تلك المنطقة المزدحمة ، ويمكن استخدام

چان ديمانچو – تطور سواحل برقة خلال الزمن الرابع .

ضمن المؤلف مقاله بعض الملاحظات الخاصة بتطور ساحل برقة فى الزمن الرابع كما سجلها فى المنطقة الواقعة ما بين بلدتى أبولونيا ودرنه وبوجه خاص منطقة رأس الهلال .

تمتاز هذه المنطقة الساحلية بوجود ثلاثة أرصفة بحرية تتمثل فى المستويات ٥٠ – ٥٥ متراً و ٣٠ متراً و ١٥ متراً . وقد عنى المؤلف بدراسة الدرجة الدنيا التى ردمتها رواسب قارية بعضها من أصل كثيبى والبعض الآخر رواسب أودية يختلط بها الحصى والرمل . وقد حفظت هذه الرواسب الرصيف من عوامل الهدم فيسرت بذلك دراسته خاصة وأن البحر ابتدأ فى إزاحة هذه الرواسب ومهاجمتها .

ويعتقد المؤلف أن الرصيف البحرى الأدنى (١٥ م) ينتمى إلى العهد الصقلى أما الرواسب الردمية فقد تكونت فى فترة « ڤرم » التى انحسر خلالها البحر ، كما يرى تشابهاً كبيراً بين عناصر القطاع الجيولوجى هنا وما شوهد فى أجزاء أخرى من سواحل البحر المتوسط فى طرابلس وإيطاليا وفلسطين .

الأستاذ م . القصاص – مظاهر السطح والغطاء النباتى فى صحراء أم درمان بالسودان .

يحصر الكاتب دراسته فى المنطقة الجافة الواقعة إلى الغرب من أم درمان ، وتبلغ مساحتها نحو ٤٤٠٠ كم٢ ، وتمتد بين خطى العرض ١٥ٌ – ١٥° و١٦° شمالا ، وبين نهر النيل شرقاً وقوز أبى دولو غرباً . ويبدأ بمعالجة مناخ المنطقة فيذكر أن أمطارها صيفية يتركز معظمها فى ثلاثة شهور (يوليو / سبتمبر) مع ستة شهور جفاف (نوفمبر / أبريل) ، هذا مع تفاوت كبير فى كمية الأمطار سواء من الناحية الزمنية أو الناحية المكانية . يضاف إلى ذلك أن النتح أعلى من المطر فى كل شهور السنة بصفة عامة .

ثم ينتقل الكاتب إلى دراسة المنطقة من الناحية الجيومورفولوجية ، ويربط بعد ذلك بين مظاهر السطح المختلفة وبين الغطاء النباتى الذى يختلف من حيث الأنواع

ومن حيث الكثافة بحسب كل من مظاهر السطح وتكوين التربة ، فضلا عن اختلافه من فصل إلى فصل ومن سنة إلى أخرى بحسب كمية الأمطار .

الدكتور عبد العزيز طريح شرف – التغيرات الحديثة للمناخ فى شمال غرب أوربا .

عقب انتهاء العصور الجليدية تعرض العالم لسلسلة من التغيرات المناخية التى كانت تشغل أحياناً بضع مئات من السنين ، وأحياناً أخرى تظهر على شكل ذبذبات لا تستمر إلا لفترات قصيرة قد لا تعدو بضع سنوات ؛ والأدلة على حدوث هذه التغيرات كثيرة ومتنوعة ، فمنها ما هو متعلق بالتطور الفيزيوغرافى لسطح الأرض ومنها ما هو متعلق بالمظاهر المناخية أو مظاهر الحياة النباتية والحيوانية ونواحى النشاط البشرى المختلفة ؛ وقد تبين بالأدلة المتنوعة أن التغيرات المناخية التى ظهرت فى شمال وشمال غرب أوربا عقب انتهاء العصر الجليدى قد شغلت عدة فترات يمكن ترتيبها كما يأتى :

ا – فترة ذات مناخ متطرف تميزت بصفة خاصة بشدة برودة فصل الشتاء ، وقبل نهايتها اشتدت حرارة فصل الصيف ، وقد بدأت هذه الفترة فى أعقاب العصر الجليدى مباشرة .

ب – فترة معتدلة كان شتاؤها يميل إلى الدفء ، ويرجح أن أمطارها كانت أكثر منها فى الوقت الحاضر ، وقد بدأت حوالى سنة ٦٠٠٠ ق . م وانتهت حوالى ٣٠٠٠ ق . م ، وفى هذه الفترة بلغت الحضارات الحجرية أوج عظمتها . وأهم الأدلة على دفئها هى : ١ – ظهور بعض أنواع الأشجار التى تتطلب الدفء مثل أشجار الليمون فى شمال غرب أوربا . ٢ – ارتفاع المستوى الذى تنمو فيه الغابات الصنوبرية على الجبال عما هو عليه فى الوقت الحاضر .

ج – عدة فترات قصيرة متتابعة بعضها جاف وبعضها رطب ، وكانت آخرها عبارة عن فترة شديدة الحرارة والجفاف استمرت حوالى قرن واحد ما بين ٨٠٠ و ٧٠٠ ق . م .

د – فترة غزيرة المطر شديدة البرودة بدأت حوالى ٥٠٠ ق . م واستمرت نحو ١٠٠٠ سنة .

ملخص المقـالات

الأستاذ ج . ﻫ . ج . ليبون — بغداد ومنطقتها .

يشير المؤلف فى مطلع مقاله إلى أهمية موقع بغداد سواء من حيث الاستغلال الزراعى أو من حيث تحكمه فى طرق المواصلات الممتدة من الشرق إلى الغرب أو من الشمال إلى الجنوب ، كما يشير إلى انتعاشها الأخير الذى ارتفع بعدد سكانها إلى ثلاثة أمثال ما كان عليه قبل ثلاثين سنة .

ثم ينتقل الكاتب إلى نشأة المدينة وتطورها منذ اتخذها الخليفة العباسى أبو جعفر المنصور عاصمة للخلافة فى سنة ١٣٦ هجرية (٧٥٤ م) إلى العصر الحاضر . ويتناول بالتفصيل البيئة الطبيعية للمدينة وما اتخذته السلطات الحاكمة على مرّ العصور من أعمال لوقاية بغداد من أخطار الفيضانات العالية التى كانت تهددها بالدمار من حين إلى حين ، حتى أصبحت المدينة الآن فى مأمن تام من تلك الأخطار بفضل المشروعات الحديثة .

ويتحدث المؤلف عن الطابع الذى تركه الحكم العثمانى فى طراز المبانى والشوارع ، وعن تطور المدينة الحديث وما أدخل عليها من تحسينات منذ سنة ١٨٦٨ ، ثم امتداد ضواحيها والتوسع فى استعمال وسائل النقل الحديثة منذ سنة ١٩٣٥ ، وكيف أن معظم الامتداد يقع فى الجانب الشرقى من النهر ، ويتجه إلى الجنوب أكثر منه إلى الشمال .

وبلغ عدد سكان بغداد (فى تعداد ١٩٤٧) ٣٢١,٢٢٥ نسمة ، وسكان ضواحيها ١٤٥,٥٠٨ . وكان اليهود وحدهم يؤلفون نحو نصف السكان ، ثم نزح معظمهم إلى إسرائيل فى عامى ١٩٥٠ و ١٩٥١ . ومع ذلك يرى المؤلف أن عدد سكان بغـداد ينمو بسرعة فى السنوات الأخيرة لأن مصانعها الحديثة وما يتوفر فيها من خدمات يجتذب عدداً متزايداً من سكان الريف المجاور .

مجلة

الجمعية الجغرافية المصرية

المجلد التاسع والعشرون

١٩٥٦

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